The Community Food Environment's Influence on Dietary Behaviors

by

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ABSTRACT

Chronic diseases are the leading causes of death in the United States. Dietary behaviors influence the risk of developing multiple chronic diseases. The U.S. population consumes too few fruits and vegetables and too much sugar sweetened beverages (SSB) and fast food. The Social Ecological Model (SEM) was created as a framework for health promotion interventions. The SEM organizes factors that can influence health into five layers: intrapersonal factors, interpersonal processes, institutional/organizational factors, community factors, and public policy. Each layer can influence dietary behaviors and other layers.

This work aims to understand how the community layer, represented by the food environment, moderates the association of two other layers and dietary behaviors: the interpersonal layer, represented by receiving health care provider's (HCP) advice to lose weight, and the policy layer, represented by participation in the Supplemental Nutrition Assistance Program (SNAP), and a policy change within the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).

Participant data were obtained from a household telephone survey of 2,211 adults in four cities in New Jersey from two cross-sectional panels in 2009-10 and 2014. Community food data were purchased and classified according to previously established protocol. Interaction and stratified analyses determined the differences in the association between HCP advice, SNAP participation, and time (for WIC participants) and eating behaviors by the food environment.

Interaction and stratified analyses revealed that HCP advice was associated with a decrease in SSB consumption when participants lived near a small grocery store, or far from a supermarket, limited service restaurant (LSR), or convenience store. SNAP participation was associated with a higher SSB consumption when respondents lived close to a small grocery store, supermarket, and LSR. There were no differences in fruit and vegetable consumption between two time points among WIC participants, or by food outlet.

The food environment, part of the community layer of SEM, moderated the relationship between the interpersonal layer and dietary behaviors and the policy layer and dietary behaviors. The association between HCP advice and dietary behaviors and SNAP participation and dietary behaviors were both influenced by the food environment in which participants lived.

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CHAPTER 1

INTRODUCTION

Chronic diseases are the leading causes of death in the United States. Heart disease and cancer alone accounted for 46% of all deaths in 2014.[1] Unfortunately, disparities exist in the risk of mortality from chronic diseases across race and ethnicities. Non-Hispanic black men have a higher death rate from heart disease, cancer, and stroke compared to Hispanic and white men and women.[2,3] Non-Hispanic black men also have the highest rate of diabetes.[4] Obesity is also highly prevalent in the United States. From 2011-2014, 36.4% of adults were obese. The rate of obesity for females was 38.1% compared to 34.5% for males. Obesity disproportionately affected non-Hispanic black women, as 56.5% were considered obese.[3]

Dietary behaviors influence the risk of developing multiple chronic diseases, including heart disease, cancer, diabetes, stroke, and obesity.[5-11] Fruits and vegetables have been shown to decrease the risk of cardiovascular disease,[5] diabetes,[6] and stroke.[7] The 2015-2020 Dietary Guidelines recommends that adults consume 2 cups of fruit daily and 2½ cups of vegetables daily, based on a 2,000 calorie diet.[12] Unfortunately, the U.S. population is not meeting this recommendation; only 13% of adults meet the recommended amount of fruit and only 9% meet the recommended amount of vegetables.[13] A 2015 study of U.S. adults found that they consume, on average, fruit 0.79 times per day and consume vegetables 1.1 times per day. Non-Hispanic blacks consume the lowest amount of fruit and vegetables, at 0.48 and 1.07 times per day, respectively. Low-income households also have the lowest fruit and vegetable consumption, at 0.68 times per day for fruit and 0.96 times per day for vegetables.[14]

Fast food is also associated with chronic disease. Frequent consumers of fast food are at higher risk for obesity[10,11] as well as diabetes.[15] Nonetheless, fast food remains a common source of calories in the American diet; during 2007-2010, adults consumed 11% of their total calories from fast food. This rate is even higher among young adults, non-Hispanic blacks, and low-income households. Among adults 20 years and older, non-Hispanic blacks consumed 14.8% of calories from fast food, the highest across all races/ethnicities. Young adults also consume higher amounts, and those with incomes below 130% of the Federal Poverty Level (FPL) consumed the greatest, at 16.6% of daily calories from fast food.[16]

Sugar sweetened beverages (SSB) are also commonly consumed; adults consume 7% of their total calories from SSB, including soda, sports drinks, and fruit-flavored drinks.[17] Similar to fast food, SSB are more commonly consumed among non-Hispanic blacks and those with lower incomes. Compared to white adults, non-Hispanic blacks and Hispanics have 1.89 higher odds and 1.25 higher odds, respectively, of consuming SSB. Low-income adults have 1.43 higher odds of consuming SSB compared to adults with incomes 300% of the FPL or greater.[18] The high rate of SSB consumption is problematic as regularly SSB consumption is associated with higher risk of developing type 2 diabetes,[9] metabolic syndrome,[9] and overweight/obesity.[8,19,20]

From individual characteristics such as income and knowledge to federal food policy that affects the nation, the factors influencing an individual's dietary choices are complex and varied. Personal relationships, work environments, and the marketing of food can all play a role in the eating behaviors of the U.S. population. Given the

numerous influencing factors in dietary behaviors, theoretical models are needed for both understanding dietary behaviors as well as informing interventions.

The Social Ecological Model (SEM) was created by Kenneth McLeroy et al. as a framework to create health promotion interventions.[21] The SEM organizes factors that can influence health into five groups: intrapersonal factors, interpersonal processes, institutional/organizational factors, community factors, and public policy. Intrapersonal factors are characteristics of the individual as they relate to health and behavior. Interpersonal processes describe the relationships and social networks, both formal and informal, in an individual's life. Institutional factors include social organizations that influence health. Community factors describe the relationships between institutional factors, such as a physical boundary of neighborhoods, a local school district, or political party. Lastly, public policy describes the laws and policies that shape the environment such as local, state, or national policies and laws.

Intrapersonal factors include an individual's characteristics such as genetics, attitude, knowledge, and beliefs regarding health and nutrition. An individual's genetics can affect their taste preferences and hormone levels, influencing which foods they choose to eat and how much of those foods.[22] Nutrition knowledge and attitudes can also influence behavior; those with more positive attitudes towards nutrition and greater knowledge of nutrition tend to eat healthier.[23,24]

Interpersonal processes describe how an individual's relationships and social networks influence health. Personal relationships influence dietary behavior. Persons with low social contact tend to eat worse, while those who are married tend to eat healthier.[25] Relationships with physicians can also influence food consumption.

Receiving doctor's advice to lose weight is associated with a number of positive eating behaviors, including less fat, less calories, and more fruit and vegetables.[26,27]

Institutional factors describe how the workplace or school environment affects the diet of those within that institution. People that work in an environment with a cafeteria are more likely to have better eating behaviors, while those who work near vending machines are more likely to have poorer eating habits.[28]

Community factors can include the built environment or food environment in a geographical area. Both the built environment and food environment can influence dietary behaviors. Living near a supermarket or small grocery store is associated with eating more fruits and vegetables.[29-33] On the other hand, living near a convenience store or fast food restaurant is associated with lower fruit and vegetable consumption.[32-34] Living near fast food restaurants is also associated with higher SSB consumption,[35] as is living in an area with a large variety of SSB available.[36] The influence of living near fast food restaurants on fast food consumption is mixed, with some finding a positive association[37,38] and others finding no or only a partial effect.[39,40]

Lastly, public policy includes local, state, or federal laws and programs, and how they can influence dietary behaviors. Federal policy influences how food is marketed through menu labeling and labeling on food packaging—both of which have been shown to influence what people consume.[41] Federal programs greatly influence the consumption patterns of low-income individuals who are often reliant on such programs for food. The Supplemental Nutrition Assistance Program (SNAP) has helped low income families improve their food security,[42] but SNAP participants tend to eat lower quality foods than income-eligible non-participants.[43] Participation in the Special Supplemental Nutrition

Program for Women, Infants, and Children (WIC) greatly improves participant's diets compared to non-WIC participants.[44] A policy change to the WIC program in 2009 revised the food package provided to participants, which led to an even greater improvement in the diets of WIC participants, increasing their whole grain, low-fat milk, and vegetable consumption.[45]

Given the many factors that can influence eating behaviors, one factor is not inherently more important than another. Each layer can influence and affect the other layers, an important part of the SEM called reciprocal causation.[21,46] One example of reciprocal causation is the policy change within WIC in 2009 to revise the food package offered to WIC participants. The revised food package introduced cash vouchers for fruits and vegetables. This federal policy not only improved participant's diets, it also improved the community through healthier food being sold within WIC-participating stores. After the policy change, WIC stores were more likely carry low-fat milk, whole wheat bread, and fresh fruit and vegetables.[47]

While much research has been done on the effect of the food environment on eating behaviors, only a few studies have examined how the food environment interacts with other layers, and these studies are limited to interventions targeting the intrapersonal layer only. A study on the influence of the food environment on the outcome of a nutrition-education based dietary intervention found that those who live near healthy food stores were more likely to increase their fruit and vegetable consumption after the intervention.[48] A similar study found that having a greater access to fresh fruits and vegetables increased the fruit and vegetable consumption of participants in a nutrition education-based dietary intervention.[49]

These studies suggest that the food environment can moderate the effect of other layer's influences on dietary behaviors. However, no research has examined the food environment's role on other layers of the SEM. Given the large role reciprocal causation plays in the SEM and the gap in literature surrounding the interaction of the food environment in other layers of the SEM, this project aims to understand the role of the food environment as a moderator within two layers of the SEM: the interpersonal layer, represented by the receipt of doctor's advice to lose weight, and the policy layer as represented by participation in the SNAP program and the policy change within the WIC program. Four key eating behaviors, fruit, vegetable, sugar sweetened beverages, and fast food consumption, will be examined based on the literature showing their association with chronic diseases as well as their association with the food environment.

Project aims:

1. To examine how the community food environment moderates the association between the interpersonal layer of the SEM, as represented by health care provider's advice to lose weight, and four dietary behaviors: fruit and vegetable consumption, fast food intake, and sugar sweetened beverage intake in an overweight and obese sample.

   Hypothesis 1-1: The association between receiving health care provider's advice to lose weight and participant frequency of fruit and vegetable consumption will be stronger among those who live closer to healthy food outlets, compared to those who do not live close to healthy food outlets.

Hypothesis 1-2: The association between health care provider's advice to lose weight and sugar sweetened beverage and fast food consumption will be weaker among those who live closer to unhealthy food outlets, compared to those who do not live near unhealthy food outlets.

2. To examine how the food environment moderates the association between the policy layer of the Social Ecological Model, as represented by participation in the Supplemental Nutrition Assistance Program (SNAP), and four dietary behaviors: fruit and vegetable consumption, fast food intake, and sugar sweetened beverage intake.

   Hypothesis 2-1: The association between SNAP participation and participant frequency of fruit and vegetable consumption will be stronger among those who live closer to healthy food outlets, compared to those who do not live close to healthy food outlets.

   Hypothesis 2-2: The association between SNAP participation and sugar sweetened beverage and fast food consumption will be weaker among those who live closer to unhealthy food outlets, compared to those who do not live near unhealthy food outlets.

3. To examine how the association between the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program, representative of the policy layer of the SEM, and fruit and vegetable consumption changed across years, and if the food environment moderates this relationship.

   Hypothesis 3-1: Fruit and vegetable consumption frequency increased from 2009 to 2014, after the introduction of fruit and vegetable vouchers in the WIC

program, and consumption frequency will be greater among those who live near healthy food outlets and WIC stores.

Delimitations:

1. Four eating behaviors will be examined (fruits and vegetables, sugar sweetened beverages, snacking, and fast food) based on their association with the health outcomes and the food environment.

Limitations:

1. Dietary behaviors, participation in government programs, and receipt of weight loss advice are all self-report.
2. Not all dietary behaviors will be examined; thus, some potential effects may not be captured.
3. All data are cross-sectional and causal inferences cannot be determined.
4. The sample is mostly low-income and from minority populations.

CHAPTER 2

REVIEW OF LITERATURE

Chronic Diseases

Cardiovascular Disease

Cardiovascular disease, including heart disease and stroke, kills more than 2,150 Americans every day.[50] In 2014, 11% of U.S. adults were living with heart disease.[51] Heart disease is also the leading cause of death in the United States; 614,348 died in 2014.[3] Non-Hispanic black men had the highest death rate from heart disease in 2014, at 259.5 per 100,000 people, compared to 215.2 for non-Hispanic white men and 145.7 for Hispanic men.[3] Women had a lower death rate than men, but displayed similar disparities across races/ethnicities; non-Hispanic black women had a death rate of 167.7 per 100,000 people, compared to 133 for white women and 92.4 for Hispanic women.[3] There are also disparities in heart disease prevalence by income. From 2013-2014, 13.7% of U.S. adults with incomes under 100% of the Federal Poverty Level (FPL) had heart disease compared to 9.3% of adults with incomes 400% or greater of the FPL.[3]

In the United States, 6.3 million people have had a stroke.[51] In 2014, it was the 5th leading cause of death with 133,103 people having died from it.[3] Data from the National Vital Statistics System reveal that disparities exist in the mortality rate from stroke. The age-adjusted death rate from stroke was 54% higher among non-Hispanic black men compared to white men, and 68% higher than Hispanic men. Women also show similar disparities; the age-adjusted stroke death rate was 30% higher for non-Hispanic black women than white women and 61% higher than the rate for Hispanic women.[2] Disparities also exist across income levels. Those that lived in counties with the lowest income

quartile had a 32% higher stroke death rate than those that lived in counties with the highest income quartile.[2]

Cancer

Cancer is the second leading cause of death in the United States; 591,699 people died of cancer in 2014.[3] Twenty million U.S. adults have been diagnosed with cancer in their lifetime, approximately 8.5% of adults.[51] Unfortunately, disparities exist in the death rates from cancer by race/ethnicity. In 2014, non-Hispanic black men had a cancer death rate of 231.9 per 100,000 people, compared to 197.7 of white non-Hispanic males, and 135.9 of Hispanic males.[3] Rates for women were lower than men, but displayed the same trend; non-Hispanic black women had the highest death rate from cancer at 156.8 per 100,000 people, compared to 142.7 for white women and 95.7 for Hispanic women.[3] Similar trends were seen for colorectal cancer; black men had a rate of 55.5 per 100,000 people, compared to 42.2 for white men, and 40 for Hispanic men. Among women, black women had a death rate due to colorectal cancer of 41 per 100,000 people, compared to 33.5 of white women, and 28.1 of Hispanic women.[3] For breast cancer, non-Hispanic white women had a highest death rate at 136.5 per 100,000, compared to 130 for black women, and 91.8 for Hispanic women.[3]

When examining cancer mortality by socioeconomic status (SES), disparities exist for all cancers as well as specific cancers. In 2010-2014, individuals in the lowest SES quintile had a 22% higher cancer mortality rate than those in the highest quintile. In 2009-2013, there was a 30% higher mortality rate from colorectal cancer in individuals in the lowest SES quintile compared to the highest quintile. Low-income women also had a higher breast cancer and cervical cancer mortality; women in the lowest SES quintile had

a 6% higher breast cancer and 76% higher cervical cancer mortality than high-income women.[52]

Diabetes

In 2014, 9.3% of adults 20 years and older in the United States had been diagnosed with diabetes and an estimated 3% were living with undiagnosed diabetes.[3] Diabetes was the 7th leading cause of death in the United States in 2014.[3] Hispanics and non-Hispanic blacks have higher rates of diabetes compared to white adults; 12.8% of Hispanic adults and 13.2% of non-Hispanic black adults had diagnosed diabetes compared to only 7.6% of white adults.[4] The prevalence of diabetes for those with incomes below 100% of the FPL was 10.9% from 2011-2014, compared to 5.5% of individuals who had 400% or greater of the FPL.[53]

Diabetes also increases the risk for other diseases. A meta-analysis of 64 cohort studies found that the relative risk for developing heart disease was 2.82 (95% CI 2.35-3.38) among women with diabetes compared to women without diabetes and was 2.16 (95% CI 1.82-2.56) in men with diabetes compared to men without diabetes. The ratio of relative risks for women to men showed that women have a 44% greater risk of developing heart disease with diabetes than men.[54]

Obesity

Obesity rates among adults continue to increase in the United States; 22.9% of U.S. adults were obese (Body Mass Index (BMI) of 30 or greater) from 1988-1994, compared to 36.4% from 2011-2014.[3] The medical costs of obesity and its related diseases are approximately $209.7 billion annually, approximately 20% of the total healthcare costs in the United States.[55]

Females have a higher rate of obesity compared to males, at 38.1% compared to 34.5%. Disparities across race/ethnicities are especially pronounced among females; 56.5% of non-Hispanic black females and 45.6% of Hispanic females were considered obese from 2011-2014. This is compared to only 24% of white males, 37.9% of non-Hispanic black males and 39.1% of Hispanic males.[3] While other chronic diseases show clear disparities by income, there are not significant differences in obesity rates by income across genders and races. All income levels show similar trends of obesity prevalence. However, among Hispanic and black men, higher income individuals have higher rates of obesity than low-income men.[56]

Obesity also increases the risk of several chronic diseases, such as heart disease, stroke, cancer, and diabetes. A pooled analysis of 97 prospective cohort studies found that the hazard ratio for heart disease was 1.69 (95% CI 1.58-1.81) among obese compared to normal weight individuals. The hazard ratio for stroke was 1.47 (95% CI 1.36-1.59) for obese individuals compared to their normal weight counterparts.[57]

Another pooled analysis of 123 cohort studies analyzed the effect of obesity contributing to the risk of developing various cardiovascular diseases, including ischemic heart disease (IHD), hypertensive heart disease, ischemic stroke, hemorrhagic stroke, as well as diabetes.[58] The researchers found that a 5 kg/m^2 higher baseline BMI resulted in a higher risk for all diseases in almost every age group (pooled data for all age groups not provided). Among those 55-64, a 5 kg/m^2 higher baseline BMI resulted in a relative risk of 1.44 (95% CI 1.40-1.48) for IHD, 1.5 (95% CI 1.40-1.60) for ischemic stroke, 1.75 (95% CI 1.44-2.13) for hemorrhagic stroke, 1.90 (95% CI 1.17-3.07) hypertensive heart disease, and 2.32 (95% CI 2.04-2.63) for diabetes.

Dietary Influences on Health

Fruit and Vegetables

The 2015-2010 Dietary Guidelines recommends that adults consume 2 cups daily of fruit and 2½ cups daily of vegetables, based on a 2,000 calorie diet.[12] The latest data from the 2013 Behavioral Risk Factor Surveillance System (BRFSS) shows that only 13% of adults met the fruit recommendations and only 9% met the vegetable recommendations. The median intake of fruit, including juice, was once per day while the median intake of vegetables was 1.7 times per day.[13] These results are similar to the 2015 State of the Plate study, conducted by the Produce for Better Health Foundation.[14] This study found that adults consumed fruit 0.79 times per day and vegetables 1.1 times per day, on average. Non-Hispanic blacks had the lowest whole fruit, excluding juice, consumption as well as the lowest total vegetable consumption, with an average of 0.48 times per day for fruit and 1.07 times per day for vegetables. Hispanics had the highest fruit and vegetable consumption with an average of 0.56 times per day for fruit and 1.11 times per day for vegetables. The lowest income groups also had the lowest fruit and vegetable consumption; households with incomes under $20,000 consumed fruit, including juice, 0.68 times per day while households with incomes over $60,000 consumed fruit 0.9 times per day. This same trend can be seen with vegetables; households under $20,000 consumed vegetables 0.96 times per day while households with incomes over $60,000 consumed vegetables 1.15 times per day.

The low frequency of consumption is problematic as fruit and vegetables have been shown to decrease the risk of mortality, cardiovascular disease, diabetes, and stroke.

A meta-analysis of prospective cohort studies found a pooled hazard ratio of all-cause mortality of 0.95 (95% CI 0.92-0.98) for each serving of fruit and vegetables per day.[5] They also found a protective effect of fruit and vegetables against cardiovascular disease mortality, with a pooled hazard ratio of 0.96 (95% CI 0.92-0.99) for each additional serving of fruit and vegetables daily.

Fruit and vegetables also appear to be protective of type 2 diabetes. A meta-analysis of 10 prospective cohort studies found that the relative risk of developing type 2 diabetes was 0.93 (95% CI 0.88-0.99) with an additional one serving of fruit a day.[6] The relative risk was 0.90 (95% CI 0.80-1.01) for each additional serving of vegetables daily. Green leafy vegetables had an even greater protective effect, with a relative risk of 0.87 (95% CI 0.81-0.93) per serving. These results are similar to another meta-analysis which found that consuming green leafy vegetables was associated with a 14% reduction in risk of type 2 diabetes.[59]

Fruit and vegetable consumption is also associated with a reduced risk of stroke. A meta-analysis of 20 prospective cohort studies found the relative risk of stroke was 0.79 (95% CI 0.75-0.84) when comparing the highest intake of fruit and vegetables with the lowest intake. For every 200 grams of fruit, there was a 32% decreased risk of stroke (95% CI 0.56‑0.82) and for every 200 grams of vegetables, there was an 11% decreased risk of stroke (95% CI 0.81‑0.98).[7]

Sugar Sweetened Beverages

While fruit and vegetables are clearly linked with improved health, many foods and beverages are associated with poor health outcomes. Sugar sweetened beverages (SSB) describe a group of beverages sweetened with sugar, and include soda, sports

drinks, and fruit-flavored drinks. Sugar sweetened beverage consumption has declined over the years but still remains high; data from the 2009-2010 National Health and Nutrition Examination Survey (NHANES) shows that adults consumed 151 calories per day from SSB, around 7% of total calories.[60] Young adults consume the greatest amount for all age groups; 20-39 year olds consumed 213 calories per day, compared to 136 calories for adults ages 40-59 years, and 68 calories for adults 60 years or older. Data from NHANES reveal that minority populations have higher odds of consuming SSB compared to white populations.[18] Non-Hispanic black adults have 1.89 higher odds of consuming any SSB than whites (95% CI 1.71-2.09) and Hispanic adults have 1.25 higher odds of consuming any SSB than whites (95% CI 1.13-1.38). Non-Hispanic Blacks are also more likely to consume regular soda (OR 1.32, 95% CI 1.18-1.48) and fruit drinks (OR 2.73, 95% CI 2.4-3.11) than whites. Those who have incomes below 135% of the Federal Poverty Level have 1.43 higher odds of consuming SSB (95% CI 1.27-1.62) than individuals with incomes 300% or greater of the Federal Poverty Level.

Sugar sweetened beverages have been associated with obesity,[8,19,20] metabolic syndrome,[9] diabetes,[9] and even early cell aging.[62,63] A four-year prospective study followed 170 post-menopausal women and measured both soda intake as well as physical activity. The researchers found that women who drank regular soda had greater weight gain (2.7±5.1 kg) than women who drank diet soda (-0.1±4.4 kg) or no soda (0.5±5.1 kg) ($F = 5.4$, $p = 0.022$).[19] These results are similar to a meta-analysis of 7 cohort studies and 5 randomized controlled trials in adults which found that one daily serving of SSB was associated with 0.22 kg of weight gain each year.[20] Te Morenga, Mallard and Mann completed a meta-analysis of randomized controlled trials and prospective cohort studies

that examined the association between sugar intake and body weight.[8] A pooled analysis of 10 intervention studies that included an increase in dietary sugar, participants in the intervention arm had an average of 0.75 kg of weight gain (95% CI: 0.30-1.19), compared to those in the control arm. Among two intervention studies lasting longer than eight weeks, the effect was even greater; participants in the intervention arm gained 2.73 kg (95% CI: 1.68-3.78) on average compared to controls.

The risk of developing diabetes and metabolic syndrome are also higher among those who regularly consume SSB. A meta-analysis of 11 prospective cohort studies found that those with the highest quintile of SSB consumption had a 26% higher risk (95% CI 1.12‑1.41) of developing type 2 diabetes than the lowest quintile.[9] The pooled relative risk of developing metabolic syndrome was 1.20 (95% CI 1.02‑1.42) for the highest intake, compared to the lowest.

The increased risk of chronic disease from SSB could in part be due to accumulation of visceral adipose tissue (VAT)[61] and early cell aging.[62,63] Cross-sectional analysis of participants from the Framingham Heart Study Offspring and Third Generation cohorts found that daily consumers of SSB had a 10% higher VAT than non-consumers.[64]

Fast Food

Fast food has increasingly become part of the American diet. During 2007-2010, adults consumed 11% of their total calories from fast food.[16] Among adults ages 20 and older, non-Hispanic blacks had the highest consumption with 14.8% of calories coming from fast food. Among young adults 20-39, those with incomes below 130% of the Federal Poverty Level had the highest intake of fast food with 16.6% of daily calories

coming from fast food, compared to only 13.8% from those with incomes over 350% of the Federal Poverty Level.

Regularly consuming fast food is concerning as fast food is high in sodium, calories, fat, and added sugars—which can lead to weight gain, obesity, and diabetes. A study that examined the food offered at Burger King, McDonald's, Subway, Taco Bell and Wendy's found that the menu offerings scored lower than 50 out of 100 points on the Healthy Eating Index (HEI). Taco Bell had the lowest score of just 39.9 out of 100 points, with Burger King at 43,8, McDonald's at 46.1, and Wendy's at 48.[65]

Duffey et al. analyzed fast food consumption frequency over a 20-year period, as part of the Coronary Artery Risk Development in Young Adults study.[11] Participants who were in the highest quartile of fast food consumption, compared to the lowest quartile, had an average of 5.6 kg higher weight (95% CI 2.1-9.2). They also had a larger waist circumference, higher triglycerides, and lower HDL cholesterol. These results are similar to a study that analyzed the diets of participants from the 1994-96 Continuing Survey of Food Intakes by Individuals and found that those who consumed fast food had higher energy intakes and lower micronutrient intakes, even after controlling for demographic and socioeconomic status. Those who consumed fast food also had a higher BMI than those who did not.[10]

Fast food may also be associated with type 2 diabetes. Using data from the Black Women's Health Study, it was found that consuming 2 or more fast food meals per week was associated with a 1.4 higher risk of developing diabetes (95% CI 1.14-1.73) for hamburgers and 1.68 (95% CI 1.36-2.08) for fried chicken, compared to those who did not eat weekly meals.[15] However, after controlling for BMI, the estimates were greatly

reduced and hamburger consumption became non-significant, suggesting BMI is a mediator for type 2 diabetes incidence.

Social Ecological Model

Social ecology studies the relationships between humans and their environment. Specifically, humans and their social, institutional, and cultural contexts.[66] Ecological models of health combine traditional behavior change theories and environmental theories to describe the interrelations between humans, environmental conditions, and health.[67] Behavior change theories have roots in psychology, and attempt to explain the processes by which people make behavioral decisions. Environmental theories describe how the physical and social environment can influence health in the following five ways: as a medium of disease transmission, as a stressor, as a source of safety or danger, as an enabler of health behaviors, and as a provider of health resources.[67] Thus, a core theory of social ecological models is that health is influenced both by personal characteristics as well as their environment, and that there is an dynamic relationship between these two.[66]

One of the original ecological models was proposed by Urie Bronfenbrenner in 1977 as a means to describe the influencers of human development.[68] In it, Bronfenbrenner separated environmental influences into four levels, each contained within the next: micro-, meso-, exo-, and macrosystem of influence. The microsystem refers to an individual's immediate surroundings and the role and activities engaged in those settings, such as being a parent at home or employee at work. The mesosystem refers to the interrelationships that shape an individual in major settings. This could include a peer group of children at school, or a social network of fellow employees at a

worksite. The exosystem extends the mesosystem and includes both formal and informal social structures in the local, state and national environment. The exosystem differs from the mesosystem in that it does not contain the person of interest but can influence the person. Lastly, the macrosystem referred to the overarching structures and activities at a cultural or societal level. These structures and activities, such as laws and regulations, influence all persons within its environment.[68]

In 1988, Kenneth McLeroy and others applied Bronfenbrenner's ecology of human development to health promotion.[21] McLeroy expanded on Bronfenbrenner's four levels to five factors which can determine health behaviors and outcomes: intrapersonal factors, interpersonal processes and primary groups, institutional factors, community factors, and public policy. Intrapersonal factors are characteristics of the individual as they relate to health and behavior, such as knowledge and attitudes. Interpersonal processes describe the relationships and social networks, both formal and informal, in an individual's life. Institutional factors can include social organizations that influence health, such as worksites or school settings. Community factors describe the relationships between institutional factors, such as a physical boundary of neighborhoods, a local school district, or political party. Lastly, public policy describes the laws and policies that shape the environment such as local, state, or national policies and laws.

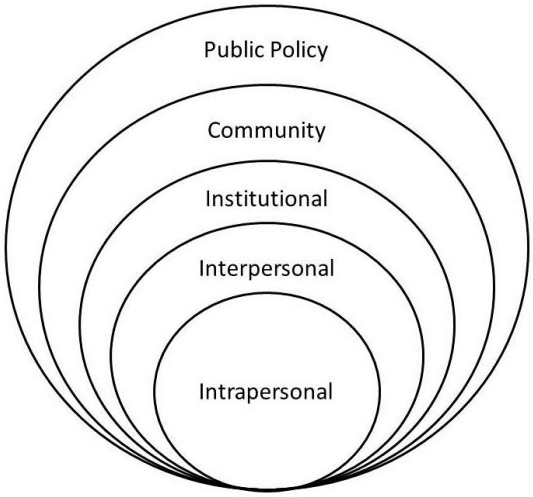


Figure 2-1: Social Ecological Model, adapted from McLeroy[21]

While each factor of the SEM can influence individual behavior, the factors are defined by the target of influence. For example, interventions aimed at the intrapersonal layer aim to change the individual's characteristics, such as knowledge or behavior. A health promotion intervention may aim to target individual behavior through peer counseling or social influence, but would still be considered an intervention at the intrapersonal level due to its focus on changing an individual's attitudes and behaviors. Interventions that focus on the community level aim to change community services, neighborhood organizations, or the social environment; these factors may then influence individual behaviors.

An important feature of McLeroy's social ecological model (SEM) is reciprocal causation, which assumes that factors at each layer can influence factors at all other levels. For example, a store may sell more unhealthy food items for lower prices with few healthy items and at a high price. This can lead individuals to buy more unhealthy food items. However, if enough individuals worked together to buy healthy items and work

with the food store manager, the store could then sell more healthy items at lower prices which could then lead to influencing other's purchasing behaviors. Further, there is no hierarchy between layers. One layer is not inherently more important than another, as all layers can influence individual behavior and other layers. Given the natural nested structure of individuals within relationships, relationships within social networks, social networks within communities, etc. – the relationship between a person and environment is a dynamic, interdependent system that is consistently changing and evolving.[21,66,69]

The SEM has been used to frame and promote many health behaviors and outcomes, including nutrition, physical activity, smoking, and obesity.[70,71] The Institute of Medicine used the SEM in their report *Preventing Childhood Obesity: Health in the Balance* to outline all factors that can influence childhood obesity. Based on their findings, they release key recommendations for future interventions in which the food industry, community programs, built environment, school and home environments all play a role in shaping children's behavior and health.[72] The Academy of Nutrition and Dietetics understands the important role the SEM plays in explaining food behaviors. In their Position Paper: *Total Diet Approach to Healthy Eating*, they state, "In addition to programs that target knowledge, skills, and behavioral practices of individuals, it is often appropriate to promote behavioral changes and dietary improvements at the broader organizational or societal levels."[73] The 2015-2020 Dietary Guidelines also discusses the SEM and states, "changes at various levels of the Social-Ecological Model is effective in improving eating and physical activity behaviors."[74] Utilizing the SEM to describe which factors can influence dietary intake is necessary for a comprehensive understanding of dietary patterns and quality to inform future public health interventions.

Intrapersonal Factors

Intrapersonal factors are characteristics of the individual as they relate to health and behavior. These can include genetics, knowledge, attitudes, health literacy, self-efficacy, and motivation. Interventions aimed at intrapersonal factors often work to improve the knowledge, attitudes, and skills needed to perform healthy behaviors.[21]

In their review article, Grimm and Steinle discuss how genetics can play a key role in dietary behavior in a number of ways.[22] Genetics can influence the number and sensitivity of taste receptors, affecting how food tastes to different individuals, which then can influence their preference and consumption of foods. Those with sensitivity to bitter foods have been shown to avoid certain fruits and vegetables as well as have a preference for sweet and fat. Genetics can also influence an individual's ghrelin and leptin levels, leading to variations in hunger, satiety, and frequency of eating.

A systematic review of 29 studies examining the association between nutrition knowledge and dietary intake found that nutrition knowledge is associated with dietary intake.[75] However, the positive association tended to be weak ($r<0.5$). Among the dietary behaviors examined, fruits and vegetables were the most likely to have an association with knowledge.

Attitudes regarding healthy eating can also play a role in dietary behaviors. Sixty two percent of U.S. adults stated time as a barrier to eating healthy in the 2011 Trends Survey.[73] Working mothers prefer to spend less than 15 minutes to prepare a meal, which can negatively impact the diet quality of meals prepared at home.

The relationship between attitudes and eating behaviors can include attitudes towards local and sustainable food production practices. A study examining college

student's attitudes and behaviors found that students who had positive attitudes towards local and sustainable practices ate more fruits and vegetables ($p<0.001$), fewer sugar sweetened beverages ($p=0.001$), and less fast food ($p<0.001$).[24]

Cooke and Papadaki examined how nutrition knowledge and attitudes influenced the use of nutrition labeling and overall diet quality in 500 young adults.[23] They found that both nutrition knowledge and attitudes independently and significantly predicted diet quality, even when controlling for nutrition labeling use.

Health literacy, defined as an individual's capacity to understand health information in order to make appropriate health decisions, and self-efficacy, the belief in one's ability to successfully perform a behavior, have been shown to be associated with diet quality. A study of 100 low-income, Hispanic adults found that both health literacy and self-efficacy were associated with positive health behaviors.[76] Self-efficacy was positively associated with both eating fruits and vegetables as well as avoiding high-fat foods. As a person's health literacy increased, the association between self-efficacy and eating behaviors became was strengthened.

An individual's motivation to lose weight is another factor that can influence dietary behaviors. A study analyzing participants from the 1996 and 2003 BRFSS found that those who mentioned they were trying to lose weight were more likely to eat more fruits and vegetables.[77] Another study examining dietary behaviors of those trying to lose weight found that they were more likely to eat more fruit ($p=0.004$), more vegetables ($p=0.01$), and more likely to eat fruit and vegetables as snacks ($p<0.001$).[26]

Interpersonal Processes and Primary Groups

Interpersonal processes describe the relationships and social networks, both formal and informal, in an individual's life. Interventions aimed at interpersonal processes may include a significant other in changing behavior or even changing a social network to influence social norms.[21]

Ferranti et al. examined various factors in the SEM that can influence and predict dietary behavior in adults working at a university and health center.[78] They measured both social support and family relationships to understand how interpersonal factors are related to three dietary patterns: the Alternate Healthy Eating Index, the Dietary Approaches to Stopping Hypertension, and the Mediterranean Diet Score. They found that perceived social support was significantly and positively related to all three dietary patterns, while family relationships did not show a significant association. Another study that examined both social and family contact found that both influenced eating behavior.[25] Adults who were single or widowed had a lower diet quality than those who were married. Having infrequent social contacts was associated with lower variety of fruit and vegetable consumption. On the other hand, having weekly contact with family was shown to be positively associated with vegetable consumption among women.

The relationship between a parent and child can affect dietary behaviors. Positive parental role modeling of healthy eating behaviors can increase the likelihood of a child accepting new foods. Parent coercion of forcing children to eat, such as "clean your plate", can negatively affect a child's ability to recognize their own feeling of fullness, possibly leading to weight gain and obesity in the future.[79] The direction of association can also be reversed between parent and child. Commonly known as the "nag factor", children can influence their parents to purchase certain foods through repeated requests.[80]

A two-year study found that children who repeatedly ask for foods while grocery shopping consumed more sugar and fat and were more likely to become overweight at a two-year follow up.[81]

Another example of an interpersonal process in the Social Ecological Model that can influence an individual's health is their relationship with their doctor and receiving doctor's advice to lose weight. Doctor's advice to lose weight has been previously associated with healthy eating behaviors, such as eating less fat and calories[27,82-85], as well as increased salad and fruit consumption.[26]

Bish et al. analyzed data from 61,546 participants of the 2000 BRFSS.[82] Adults who received doctor's advice to lose weight had 1.25 higher odds of reporting eating fewer calories than those who did not receive advice. This is similar to the findings by Loureiro and Nayga, who used 2001-2003 BRFSS survey data.[27] They found that individuals who received advice to lose weight from their physician were more likely to eat fewer calories and less fat.

Dorsey and Songer examined the influence of doctor's advice to lose weight in a diabetic population.[84] They analyzed data from the 2006 National Health Interview Survey, limiting analysis to overweight and obese people 40 years or older with prediabetes or diabetes (n=1,442). They found that men with diabetes had 11.3 higher odds (95% CI 6.7-19.0) of reducing fat or calories in their diet after receiving weight loss advice compared to those who did not receive advice. Women with diabetes had 5.7 higher odds (95% CI 3.7-8.6).

Another study interviewed patients immediately after their primary care appointment and followed up with them one year later to determine any behavior or

weight loss change.[85] They found that patients who received doctor's advice on their health lost 1kg compared to those who did not receive advice, who gained 0.3 kg (p=0.02). Patients reported the strategies used to lose weight, of which "modified diet to lose weight" was listed. While the prevalence of this strategy was higher among those who received advice, it only approached significance (p=0.09) compared to those who did not receive advice.

Most studies to date have examined changes in general eating behaviors after receiving weight loss advice, such as eating fewer calories or fat. A recent study examined the association between weight loss advice and eating specific foods.[26] The authors found that in an obese population, receiving advice to lose weight from a health care provider was associated with a higher fruit consumption and higher salad consumption than those who did not report receiving weight loss advice (p=0.03 and 0.01, respectively).

A recent meta-analysis that examined the influence of doctor's advice to lose weight found a mean weighted odds ratio of 3.85 for patient weight loss efforts of those who received advice, compared to those who did not.[83] The authors' conclusion was that physician advice to lose weight has a significant impact on patient's weight loss behaviors.

Unfortunately, the prevalence of weight loss advice is still low. A study by Loprinzi and Davis found that among the NHANES 2011-2012 participants, only 19.4% of overweight participants received advice to lose weight.[86] As BMI increased, so did the ratio of those who received advice to lose weight, with 46.8% of obese class 1 received

advice, 62.8% of obese class 2, and 76.9% of obese class 3 receiving advice to lose weight from their health care provider.

To date, studies that have examined doctor's advice to lose weight have not examined moderators to the relationship between doctor's advice and behavior change. This gap in literature requires future studies to examine potential moderators to better understanding this relationship.

Institutional/Organizational Factors

Institutional factors include both formal and informal social organizations. These may include workplaces, day cares, and educational settings. Interventions aimed at organizational factors may include worksite wellness programs or nutrition promotion in schools.[21]

Worksite wellness programs are a key strategy to improve the health of working adults and foster a healthy work environment. A study examining the effect of the work environment on health found that access to food matters; having a cafeteria present was associated with better eating habits (β=-0.51, $p<0.001$) and the presence of vending machines was associated with poor eating habits (β=0.04, $p<0.05$).[28]

The American Heart Association recommends that environmental changes be included in all worksite wellness programs, to encourage healthy behaviors.[87] Unfortunately, most worksite wellness programs use the worksite as a place for providing education to employees rather than change the work environment itself. A review of 47 worksite wellness interventions found that only eight included an environmental or policy component.[88] A separate review of wellness programs that specifically included environmental changes concluding there was strong evidence that modifying the food

environment can result in an improvement of dietary behaviors. The strategies used in the studies included expanding healthy food options, altering food prices, and placing signs at point-of-purchase.[89] Given the research to support environmental changes in work environments and national recommendations, more worksite wellness programs should include environmental changes in their program and study which strategies are most effective in producing dietary change.

As discussed previously, physicians play a key role in influencing the health of individuals. The National Health Interview Survey found that in 2014, 81% of U.S. adults visited a health care professional at least once during the past 12 months.[51] The U.S. Preventive Services Task Force recommends that all adult patients are screened for obesity by their health care provider and offer the appropriate treatment as needed.[90] A review of policy and environmental approaches to improve health found that one of the interventions with the strongest evidence for promoting nutrition was by training health care providers to provide nutrition counseling.[91]

Unfortunately, many physicians and health care providers are not meeting national guidelines to provide weight loss advice to all obese patients. A study by Breitkopf et al. surveyed 2,138 overweight and obese low-income women, as part of a cervical cancer prevention trial.[92] Of the 2,138 women, only 15% of overweight women (BMI 25-29.9), 34% of obese (BMI 30-34.9), and 57% of women with BMI 35-39.9 had reported receiving weight loss advice. Another study found that of 548 obese, low-income adults, only 48% reported receiving advice to lose weight.[26]

A review of seven studies examining barriers to providing weight loss counseling found that the number one reason cited by health care providers was lack of time, and

then second most cited reason was lack of training/knowledge. A lack of knowledge of both nutrition as well as counseling techniques was discussed in five of the seven studies.[93] Similarly, a study by Steeves et al. analyzed the results from the National Survey of Energy Balance-Related Care among Primary Care Physicians.[94] Among the 2,022 primary care physicians surveyed, almost all (97%) felt it was their responsibility to provide weight-related care. However, 63% felt they did not have the skills or strategies to actually do so.

One reason many physicians may not feel knowledgeable about providing weight loss or nutrition advice is that nutrition education is still lacking in medical education. A recent study by Adams et al. surveyed all U.S. medical schools to determine their extent of nutrition education.[95] The National Research Council recommends schools provide 25-30 hours of nutrition education to medical school curriculum. Of 121 medical schools surveyed in the study, only 29% met this recommendation. Thirty six percent of schools provided less than half the recommendation. This is problematic as providing nutrition curriculum has been associated with an improvement in dietary assessment ability, counseling confidence, and even improvement with medical student nutrition-related attitudes and behaviors.[96] Organizational changes across all medical school curriculums are needed so that future physicians are given the nutrition education they require to make appropriate patient care decisions.

Community Factors

Community factors describe the relationships between institutional factors and internal processes. There are many definitions of the term community, and may refer to a geographical location or the psychological sense of a community, such as a political party

or religious organization. As described by McLeroy et al., an important part of community is the social resources and social identity, known as "mediating structures." These mediating structures can influence individual's attitudes and behaviors and are an important part of health promotion interventions.[21]

As part of the community layer, the food environment has a large influence over an individual's access to food, which then affects food and nutrient intake. Most of the research on the community food environment has examined fruit and vegetable consumption. Morland, Wing, and Roux analyzed the diet of 10,623 participants in the Atherosclerosis Risk in Communities and geocoded retail and restaurant stores by census tract.[29] Among Black participants, the presence of a supermarket in their census tract resulted in higher relative risk of meeting dietary guidelines for fruits and vegetables (RR 1.54, 95% CI 1.11-2.12), even when controlling for income, education, and other types of food outlets. Living in a census tract with a supermarket also increased the likelihood of meeting total fat and saturated fat recommendations (RR 1.22, 95% CI 1.03-1.44 and RR 1.30, 95% CI 1.07-1.56, respectively). White participants showed similar trends, but the magnitude of the association was not as significant.

Bodor et al. found similar results among residents living in New Orleans.[30] Individuals that lived within 100 meters (approximately the size of a city block) of a small grocery store that had fresh vegetables were more likely to consume fresh vegetables and each additional meter of shelf space within that store corresponded to 0.35 more servings of vegetables per day ($p=0.025$). These findings are similar to another study which found that those living close to a large grocery store ate 0.69 more servings daily of fruits and vegetables than those who did not live close to a large grocery store.[32]

This association was stronger among Hispanics, who consumed 2.2 more servings daily. Also, living close to a convenience store resulted in 1.84 fewer servings daily of fruits and vegetables.

A study by Zenk et al. examined fruit and vegetable intake and shopping habits and found that African American women who shopped at supermarkets consumed more fruit and vegetables than those who shopped at small grocery stores.[31] Shopping at a supermarket resulted in consuming fruit 1.22 more times daily ($p<0.001$) and vegetables 2.37 times more daily ($p<0.05$). They also found those with higher incomes were more likely to shop at a supermarket ($p<0.01$); thus, income may indirectly be tied to intake through store choice.

Among participants in the Supplemental Nutrition Assistance Program (SNAP), living close to healthy food stores is associated with healthier eating. Among 147 SNAP participants, living within 0.5 miles of a farmer's market or produce stand resulted in 6.92 higher odds of consuming at least one serving of vegetables daily (95% CI 4.09-11.69). Living within 0.5 miles of a retail store that sold healthy food resulted in 3.07 higher odds of consuming vegetables (95% CI 1.78-5.31).[97]

LeDoux and Vojnovic studied how both distance to and count of different retail outlets can influence dietary behavior.[33] While the number of supermarkets within one-quarter mile was significantly and positively associated with fruit and vegetable consumption, the effect waned beyond one-quarter mile. However, living within both a one-quarter and half-mile radius to fast food outlets was negatively related to fruit and vegetable consumption; thus it appears that the effect of the presence of fast food outlets outweighs the positive attributes of a supermarket. The authors conclude that the overall

food environment composition may be more important to dietary behaviors than distance to a single supermarket.

The negative effects of fast food restaurants were also seen in a study of 1,345 individuals in Genesee County, Michigan.[34] Survey participants who lived close to fast-food restaurants ate lower amounts of fruits and vegetables (β=-0.034, $p<0.008$) and also had higher BMIs (β=0.088, $p<0.001$).

Interestingly, it may not be the objective measure of the food environment that influences dietary behavior but the perceived environment. A study by Caspie et al. surveyed 828 low-income households in the Boston area and found that distance to a supermarket was not associated with fruit and vegetable intake ($p=0.22$).[98] However, the survey participants were also asked if they had a supermarket "within walking distance." Those who perceived a supermarket to be within walking distance had a higher fruit and vegetable intake ($p<0.001$). However, a study by Gase et al. also examined the perceived environment and found different results.[99] The researchers surveyed 1,503 low-income adults in Los Angeles and collected their self-reported time and distance to the nearest grocery store. The researchers found no association between time or distance to the grocery store and any dietary behaviors, including fruit, vegetable, and SSB consumption.

The research on the community food environment's influence on SSB consumption among adults is not as robust as the research on fruit and vegetable consumption, and has mixed results. As part of the Pound for Prevention study, French et al. surveyed 891 women ages 20-45 both at baseline and at a 3 year follow up.[100] They found that an increase in one fast food meal per week was associated with an increase in

0.10 servings of soda per day (p=0.01) over a 3 year period. This study only examined frequency of fast food and dietary behaviors though, and did not examine the community food environment. A similar study by Wiecha et al. examined the dietary habits of 1,474 middle school aged students.[101] They found that, compared to students who did not visit a fast food restaurant within the past week, students who had visited a fast food restaurant once within the past week ate 0.13 more servings of SSB (p=0.07), students who visited two to three times ate 0.49 more servings (p=0.001), and students who visited four or more times ate 1.64 more servings of SSB.

A study among 349 adolescents (mean age, 15.4 years) in Minneapolis found a significant relationship of SSB consumption with proximity to fast food restaurants and food retail stores.[35] There was a positive relationship with having a fast food restaurant within 1,600 m of home (β=0.25, 95% CI 0.05-0.44) and a convenience store within 1,600 m of home (β=0.24, 95% CI 0.06-0.41). Interestingly, a study by Gustafson et al. surveyed 121 adults in Lexington, Kentucky to examine the association of dietary behaviors and food stores.[102] The authors found that those who shopped frequently at a supermarket had a higher odds of consuming SSB (OR 1.39, 95% CI 1.03-1.86) compared to those who never shopped at supermarkets. However, if they shopped in a supermarket with a large variety of healthy foods, their odds of consuming SSB were lower (OR 0.65, 95% CI 0.14-0.83). There was no association between shopping at convenience stores and SSB.

A study in Sao Paulo, Brazil examined 1,842 adults in 52 census tracts.[36] The researchers conducted in store audits in these census tracts of availability and variety of SSB. Adults that lived in a census tract with a greater variety of SSB (defined as above

the median of number of brands and flavors) were more likely to consume SSB (PR 1.26, 95% CI 1.02-1.55) compared to those who did not.

The community food environment's association with fast food intake is mixed. As part of the 2000-2002 Multi-Ethnic Study of Atherosclerosis, Moore et al. examined the association of fast food consumption with exposure to fast food restaurants in the local neighborhood.[37] Fast food exposure was determined by self-report availability of fast food, Geographic Information System (GIS) mapping of the density of fast food outlets per square mile, and 'informant report,' which was an average of neighboring participants report. All three measures were associated with higher fast food consumption, although the objective GIS mapping only approached significance. Participants who lived in areas of a higher number of fast food outlets, according to self-report, had 61% higher odds of consuming fast food (95% CI 1.51-1.72) compared to those who self-reported lower number of fast food outlets. Informant reports were associated with 27% higher odds of consuming fast food (95% CI 1.17, 1.39) compared to those with lower reported fast food outlets. GIS mapping revealed an odds ratio of 1.11 (95% CI 0.98-1.26).

A study in central Texas by Dunn et al. surveyed 1,019 adults, as part of the Brazos Valley Health Community Health Assessment.[38] This sample was predominantly white, at 82%, with 18% non-white (including Hispanic and black). Fast food outlet data was collected by ground-truthing in the area. Availability was determined by three measures: the distance to the nearest fast food restaurant, the number of restaurants within 1 mile of the participant's home, and the number within 3 miles. The researchers found that greater fast food availability was not associated with greater consumption of fast food among whites; however, greater availability was associated with higher fast

food consumption among non-white participants. Both distance to the nearest fast food restaurant and the number of fast food restaurants within 3 miles were significantly associated with fast food consumption among non-whites.

A study by Oexle et al. surveyed 838 households in eight counties in South Carolina.[39] Fast food consumption and perceived fast food availability was self-reported and GIS mapping was used to determine the location and number of fast food restaurants in each participant's neighborhood. There was no association between objective or perceived fast food availability within 1 mile of the home and intake. However, there was not a large variability among fast food access—85% of participants did not have a fast food outlet within 1 mile of their home, and the researchers did not look at proximities beyond 1 mile.

A telephone survey of 1,033 Minnesota adults examined the association of fast food consumption with proximity to and density of fast food restaurants around both the participant's home and work.[40] Participants were mostly female (69%) and educated (75% had some college or college degree). Proximity was determined by GIS mapping, and included radii of ½ mile, 1 mile, and 2 miles. Density was determined by the number of restaurants. There were no significant associations with proximity; however, the number of restaurants within a 2 mile radius of the participant's home was positively associated with fast food consumption ($\beta=0.301$, $p=0.01$).

Research shows a trend in disparities of access of retail and restaurant outlets by race and income, although some results are mixed. A review of community food environment studies found that in the United States, those who live in low income and

predominantly minority neighborhoods have lower access to healthy foods compared to wealthier and white neighborhoods.[103]

A study by Bower et al. examined neighborhood demographic composition, according to U.S. Census data, and its association with the number and type of food outlets.[104] They examined 65,174 census tracts in both urban and rural areas. The researchers found that census tracts that were predominantly black had the fewest supermarkets while white census tracts had the most. Controlling for race/ethnicity, as neighborhood income decreased, the number of supermarkets also decreased and the number of small grocery and convenience stores increased.

Powell et al. examined food outlets across 28,050 zip codes in the United States.[105] They found that low-income neighborhoods had only 75% of the supermarkets as middle-income neighborhoods ($p<0.01$). Predominantly black neighborhoods had only 52% of the supermarkets as white neighborhoods ($p<0.01$), even when controlling for income.

A similar study examined the association of 28,050 zip codes with types of restaurants.[106] Low-income neighborhoods had 1.24 (95% CI 1.18-1.30) times the number of fast food restaurants as high-income neighborhoods, near-low had 1.34 times (95% CI 1.28-1.40), and middle-income neighborhoods had 1.28 times (1.22-1.34) as many fast food restaurants. Predominantly black neighborhoods had fewer fast food restaurants (IR=0.60, 95% CI 0.54-0.65) compared to white neighborhoods.

James et al. also examined the association between fast food access and neighborhood demographics.[107] They examined census block groups for percent population that was black and the percent below poverty. The driving distance from the

population-weighted center of each block group to the five closest top ten fast food chains was then calculated. They found that block groups with the highest percentage of black residents had fast food that was three miles closer than block groups with the lowest percentage of black residents. They also found that those with the highest incomes (less than 13.8% below poverty) had higher access to fast food than block groups with the lowest incomes (greater than 40% of population below poverty).

The community food environment's effect on dietary intake is complex. Supermarkets appear to play a positive role in increasing fruit and vegetable intake among shoppers, but those shoppers may be of higher income and already have positive perceptions regarding the supermarket. Supermarkets also have mixed results with the association with SSB, perhaps due to the greater variety of SSB found within them. Lastly, living near fast food restaurants has mixed results on dietary intake, and disparities in fast food access exist across income and racial neighborhoods.

Public Policy

Public policy describes the laws and policies that shape the environment. It can include local, state, or national policies, procedures, or laws. Examples of interventions that target public policy can be laws used to restrict unhealthy behaviors, allocating money for health programs, or establishing health promotion programs.[21]

The marketing of food is heavily influenced by policy.[108] Menu labeling, nutrient and health claims, and the nutrition facts panel are all influenced by national policy and can influence consumption patterns. Starting May 2018, the Patient Protection and Affordable Care Act will require restaurants with 20 or more locations to post calorie information on menus and vending machine operators who have 20 or more vending

machines to post calorie information for foods in the vending machine.[109] A study by Roberto et al. evaluated the impact of menu labeling on food ordering and consumption behaviors. They found that participants who ordered food from a menu with calories posted ate 14% fewer calories than participants who ordered food from a menu with no calories listed.[41] Another study found that people who used menu labeling were more likely to order healthier beverages and sides at fast food restaurants.[110] Unfortunately, those with lower incomes are less likely to use calorie labels on menus. One study found that individuals with incomes $50,000-99,000 had 3.5 greater odds of using calorie labeling to make purchase decisions than individuals with incomes below $50,000.[111]

The Nutrition Facts label is another manner in which national policy can influence dietary behaviors. A study by Post et al. examined the use of the Nutrition Facts Label by adults who participated in the 2005-6 NHANES and were diagnosed with type 2 diabetes, hypertension, or hyperlipidemia.[112] The researchers found that those who read the Nutrition Facts label, compared to those who did not read the label, ate fewer calories (2,058 vs. 2,251, p=0.01), saturated fat (26.8 g vs. 29.2 g, p=0.04), and sugar (105.4 g vs 126.4 g, p=0.001), and more fiber (16 g vs 14.5 g, p=0.01).

In May of 2016, the United States Food and Drug Administration released the new Nutrition Facts label to be used on packaged foods.[113] The new label will take effect starting July 26, 2018. Smaller companies (less than $10 million in annual sales) will have until 2019 to begin using the new panel. The new label will include added sugars, replace vitamins A and C with vitamin D and potassium, and has a new look with emphasizes the serving size and calories. How the new label will influence dietary behaviors compared to the old label remains to be seen.

Government nutrition programs, such as SNAP and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), assist low-income families in purchasing food. While food insecurity has declined in recent years, it remains a public health issue in the United States. In 2015, an estimated 15.8 million households, 12.7% of the population, were food insecure at least some time during the year.[114] The Supplemental Nutrition Assistance Program, formerly known as the Food Stamp Program, officially began in 1964 with the Food Stamp Act of 1964. SNAP provides money via an electronic card for individuals and families to purchase food and is considered the first defense against hunger. In Fiscal Year 2015, SNAP provided benefits to 45,767 individuals with an average monthly benefit of $126.83 per person.[115]

There are mixed results when it comes to SNAP program participation and diet quality.[43,116] The goal of SNAP is to reduce food security, to which it is successful.[42] However, the food that participants choose to purchase may not be healthy.

A recent systematic review by Andreveya et al. summarized 25 studies from January 2003 to August 2014 that examined the association of SNAP participation and diet quality.[43] Studies included both local, convenient samples as well as large, national samples, such as NHANES, Consumer Expenditure Survey, Continuing Survey of Food Intakes by Individuals (CSFII) and the Current Population Survey. Sixteen of the 25 studies included data on adults. Most studies did not find a difference in fruit and vegetable consumption between SNAP participants and income-eligible nonparticipants; however, one study using a nationally representative sample found a higher consumption of whole fruit among SNAP participants. All four studies that examined SNAP participants and consumption of food away from home found that participants ate less

food away from home than nonparticipants. Among ten studies that examined SSB consumption and SNAP participation, four found a higher consumption among SNAP participants and six did not find a difference.

A study by Todd and Ver Ploeg used NHANES 2005-2008 data to examine SSB consumption among SNAP participants compared to individuals who made up to 250% of the FPL, higher than the 130% guideline for participating in SNAP. They found no differences in SSB consumption between SNAP and non-SNAP participants.[117] However, a study by Bleich et al. used NHANES 2003-2010 data and found that SSB consumption was higher among SNAP participants (210 kcal/day) than income-eligible non-participants (192 kcal/day), which were defined as individuals with incomes below 130% of the FPL, but this difference was not statistically significant.[118]

A 2013 report by the United States Department of Agriculture's Economic Research Service examined the association between SNAP participation and diet quality.[116] They used data from four waves of NHANES from 2001-02, 2003-04, 2005-06, and 2007-08. SNAP participants were those that said they had participated in SNAP within the past 30 days. Nonparticipants were persons with incomes up to 200% of the FPL. The primary outcome was the HEI score of participants and nonparticipants. SNAP participants had a lower HEI score compared to nonparticipants (47.2 vs. 51.3, $p<0.01$). Total fruit servings (1.7 vs 2.1), whole fruit servings (1.3 vs. 1.9), and total vegetables servings (2.7 vs. 3) were also lower among SNAP participants compared to nonparticipants ($p<0.01$ for all).

Nguyen et al. examined the association with SNAP participation and diet quality using NHANES data from waves 2003-2010.[119] Income eligible nonparticipants were

chosen based on a household income <130% of the FPL. The primary outcome was the total HEI score, but the researchers also examined scores for fruit and vegetables. SNAP participants had a lower HEI score than nonparticipants (44.36 vs. 42.58, $p<0.05$), as well as a lower total vegetables score (2.62 vs 2.84), total fruits score (1.68 vs. 1.91), and whole fruits score (1.42 vs. 1.63) ($p<0.05$ for all). These results align with a study by Leung et al. which used data from NHANES 1999-2008 and found SNAP participants consumed few whole grains, more red meat, and in women, more SSB, compared to income-eligible non-participants.[120] They also found that SNAP participants had a lower dietary quality score than income-eligible non-participants.

Unfortunately, most SNAP-authorized stores do not carry a variety of healthy foods. A study by Laska et al. examined store audits of SNAP-authorized retailers and found only 31% of stores carried fresh vegetables and 26% sold whole grain bread.[121] Another study that audited the food sold in corner stores found that SNAP stores scored significantly lower on the Nutrition Environment Measures Survey for Corner Stores tool than both non-SNAP stores and WIC stores.[122]

While SNAP provides money to participants to purchase any type of food, WIC provides vouchers to participants for specific, healthy foods, as well as nutrition education and referrals for healthcare. In 2007, the USDA published an interim rule to update the WIC food package starting October 1, 2009.[123] The revised food package added whole grains, soy products, legumes, cash value vouchers (CVV) for fruit and vegetables, required low fat milk for children over the age of 2 and adults, and decreased the total amount of fruit juice, milk, and eggs provided to families. The amount of CVV at the beginning of the guideline change varied by participant; children received $6 a

month, women who were not breastfeeding received $8 a month, and breastfeeding women received $10 a month.

The research on the effect of WIC participation is clearer—participants in WIC consume healthier diets than non-participants. Analysis of households that participated in the 1989-91 CSFII showed that WIC households have an average of 23 more points on the HEI than non-participating households.[44]

The revised food package showed an even greater benefit to WIC participants. Whaley et al. conducted random telephone surveys among WIC participants in California before and six months after the revised food package implementation.[45] They found that after the new program guidelines, participants who reported consuming more whole grains increased 17% ($p<0.001$) and lower-fat milk increased 14% ($p<0.001$). While participants reported consuming more vegetables, mean vegetable intake was not significant before and after the guideline change; however, fruit intake did increase slightly from 1.26 to 1.38 times per day ($p=0.01$). A study in Illinois found similar results; six months after the new WIC program changes, fruit consumption increased among Hispanic mothers by 0.33 servings per day ($p=0.04$) and low-fat dairy increased by 0.21 servings per day ($p=0.02$).[124] However, a study that used a longer follow-up period of 18 months after the new guideline found no change in adult eating behaviors.[125]

In June 2014, New Jersey implemented a requirement for WIC-authorized stores to begin carrying two different types of fresh fruit and two different types of fresh vegetables. Prior to this rule, WIC-stores were able to carry fresh, canned, or frozen. Okeke et al. examined CVV redemption in NJ before and after this guideline change and found a higher odds of families using at least 90% of their CVV after this new

requirement, compared to before (OR 1.10, 95% CI 1.04, 1.17).[126] Interestingly, for households that lived in census tracts with at least one healthy food store, the odds were slightly higher (OR 1.13, 95% CI 1.06, 1.20). While the percentage of WIC households redeeming at least 90% of their CVV did increase after the new requirement, it was still relatively low at 56.9%.

The revised WIC food package influenced more than just WIC participants, stores that accepted WIC vouchers also improved their food sold in store. A study among small stores in New Orleans showed that WIC stores were more likely to carry low-fat milk than non-WIC stores (OR 5.0, 95% CI 1.2-21.0), whole wheat bread (OR 160.3, 95% CI 16.2-1,583.3), and brown rice (OR 62.3, 95% CI 12.1-319.3).[47] WIC-participating stores also increased the amount of fresh fruit ($p<0.01$) and total vegetables ($p<0.01$). These results are similar in a study conducted in stores in low-income areas of Philadelphia.[127] Stores were rated using the Nutrition Environment Measure Survey for Stores (NEMS-S) instrument before and after the WIC program changes. After the WIC revised food package, the availability of healthy food increased in all stores, and even more so in WIC stores. Healthy food availability scores increased from 11.9 at baseline to 16.0 in corner stores ($p<0.001$) and from 12.9 to 16.8 at all stores, including grocery stores and supermarkets ($p<0.001$).

Reciprocal Causation & Interactions in the SEM

An important aspect of an ecological view of health is reciprocal causation; that is, the environmental conditions influence individual behaviors and that individual behaviors can, and should, influence their environment.[21,69]

Given the foundational aspect of reciprocal causation in the SEM, understanding how each factor influences individual behaviors as well as other factors is necessary for a comprehensive understanding of dietary patterns and quality. Unfortunately, most nutrition interventions and studies that examine determinants of eating behavior have focused on the intrapersonal (individual) and interpersonal factors only, often ignoring the community and policy layers.[71,128] A review of 62 nutrition-related interventions found that while 95% included intrapersonal factors, only 11% contained community level factors, and only 3% contained policy-level activities.[71] This is problematic given the large roles the community layer and policy layer play in the dietary choices of individuals, especially those who are low-income.

The number of observational studies describing the effect of the food environment on dietary behaviors is robust. However, research is still lacking on how the food environment interacts with other layers of the SEM to influence dietary behaviors.[129,130]

Gustafson et al. examined how the availability of supermarkets moderated the effectiveness of a 16-week nutrition intervention on fruit and vegetable intake among low-income women.[129] Participants included 156 women ages 40-64 who had a household income ≤250% of the FPL who lived in six counties in North Carolina, both rural and urban. Fifty six percent of the participants were black, 40% were white and 4% were other. There were no significant differences in fruit and vegetable consumption, or perceived or objective food environment variables between the two groups at baseline. The intervention group of the 16-week study included weekly group sessions on an education topic and activity related to diet or physical activity. The intervention also included goal setting and action planning. The community food environment data was

purchased from InfoUSA and classified according to the Standard Industrial Classification (SIC) codes. Stores were then mapped to each participant's census tract. The researchers created a variable of both total count of each store as well as a dichotomous variable based on availability of each store type in each census track (none or 1+). The researchers also asked each participant which store they did most of their shopping. In-store assessments were completed for these stores and a proximity variable was created for each participant to their primary store. Fruit and vegetable consumption was captured by a validated rapid food frequency survey. The only food environment variable that showed significant results was the total counts for supermarket. Interestingly, participants in the intervention who lived in an area with a low density of supermarkets had a greater intervention effect on an increase in fruit and vegetable consumption relative to controls (1.62, 95% CI 1.27-1.96). The authors explained this could be due to the intervention increasing the motivation of the participants to find sources of fruits and vegetables when living in an area of poor fruit and vegetable availability.

Similar results were seen in a study that examined the built environment on a physical activity intervention.[131] Twelve months post-baseline, men in the intervention group increased their walking by 29 minutes when living in less walkable neighborhoods compared to men living in highly walkable neighborhoods who had decreased their walking by 10 minutes daily ($p<0.02$). The authors conclude that the intervention may be even more effective in low walkable neighborhoods, as people who live in highly walkable neighborhoods walked more at baseline.

A study by Wedick et al. examined how the food environment moderated the effect of a dietary intervention on 204 obese participants in Worcester County, Massachusetts.[48] Participants were 72% women and 89% non-Hispanic white. Participants were randomized to one of two conditions: the American Heart Association Dietary Guidelines or a dietary pattern that focuses exclusively on increasing fiber intake. Both conditions included 12 groups sessions and two individual sessions. This study used participants from both conditions that had completed dietary data for baseline and follow-up as well as living in neighborhoods where food environment data was collected. Dietary intake was captured via a 24-hour recalls at baseline and then at three, six, and 12 months post-intervention via telephone. Each dietary measurement window included two weekdays and one weekend day. Grocery store data was collected through both on-site surveying and purchasing data from InfoUSA. All grocery stores were surveyed annually using the Community Nutrition Environment Evaluation Data System (C-NEEDS), a modification of the Nutrition Environment Measures Survey. A Healthy Food Availability (HFA) Index was created for each store from the C-NEEDS results, with a range of 0-33. A higher point value indicates greater availability of healthy foods. Distance to the nearest food store with adequate HFA was calculated for each participant. Densities were also calculated for the number of healthy food stores (HFAI $\geq$20) within 1/2, 1, 2, and 3 miles. There were no significant differences between the two interventions' conditions and distance to nearest store at baseline. There were also no differences in fruit and vegetable servings post-intervention by the type of condition. The researchers found that a shorter distance to a healthy food store was associated with greater increase in fruit and vegetable consumption (β=-0.19 servings/day per mile,

p=0.03) among intervention participants. This association was unchanged after adjusting for participant demographic factors. This association was significant for the first three months post-intervention, but lost significance at 6 months and 12 months post-intervention. The researchers conclude that the food environment significantly influences the effectiveness of nutrition interventions in changing dietary behaviors.

Feathers et al. examined how access to fruit and vegetables could influence both the enrollment and adherence to a randomized dietary modification trial among Hispanic, Spanish-speaking breast cancer survivors.[49] Seventy women were recruited from the Columbia University Medical Center in New York. However, 21 participants stated that another family member did most of the grocery store shopping and thus were dropped from the analysis. Participants were mostly low income (70% had household income below $15,000) and 60% had a high school degree or below. The intervention consisted of a nine-session program that included nutrition education, cooking classes, and grocery store tours. The control consisted of standard practice, which was being given written materials that explained the dietary guidelines for cancer survivors. Participants who enrolled in the trial lived in an environment with higher access to produce compared to those who did not enroll (12.7 outlets vs. 9.7 outlets), although the difference only approached significance (p=0.07). Women who were in the intervention increased their fruit and vegetable consumption by two servings per day compared to the control group which decreased their fruit and vegetable consumption by 0.1 servings (p<0.01). Among the women in the intervention group who self-reported doing the grocery shopping, those who lived in an environment with higher access to produce trended toward higher fruit and vegetable consumption compared to women who had lower access to produce (3.1

vs. 1.6 servings). However, the trend was non-significant (p=0.24), potentially due to the small number of participants (n=22).

Epstein et al. examined the relationship between the neighborhood environment and if it moderates the effectiveness of weight loss interventions among children.[132] Participants included 191 overweight and obese children ages 8-12 who lived in Erie County, New York. The study included participants from four different randomized controlled studies in the intervention arm only. The number of treatment sessions ranged from 16-20 for each study. Seven neighborhood environment variables were examined within a ½ mile radius of each participant's home: housing density, intersection density, park area, park+recreational area, and the number of supermarkets, grocery stores, and convenience stores. Community food environment data was purchased from Reference USA and verified by calling business owners if the description of the business and the SIC code did not match. Grocery stores and supermarkets were differentiated by the number of employees—stores with fewer than 50 employees were classified as a grocery store and stores with more than 50 employees were classified as a supermarket. The primary outcome variable was BMI. The researchers found that children who lived near a fewer convenience stores at six (p=0.007) and 12 months (p=0.02) and fewer supermarkets at six (p<0.001), 12 (p=0.006), and 24 months (p=0.001) had greater reductions in BMI 2 years post-intervention across all four interventions. The authors conclude that fewer convenience stores would provide less access to unhealthy snack foods. While supermarkets provide a greater variety of fruits and vegetables, they could also provide a greater variety of unhealthy foods, which may cause less weight loss than shopping at stores with fewer varieties of unhealthy foods.

The influence of the environment on SNAP participation and diet is unknown. A review paper of SNAP participation and obesity by DeBono et al. calls for more research to understand how obesogenic environments affect SNAP participants.[133] SNAP participants are at higher risk for obesity than non-participants. The authors hypothesize that eligible non-participants may live in healthier environments than participants. However, research is needed to support this hypothesis.

CHAPTER 3

METHODS

Study Design

The New Jersey Child Health Study is a longitudinal study examining the impact of the food and physical activity environment both in and around schools on children's weight and health behaviors. The study is collecting data on the child and an adult relative. The study has collected data in four cities in New Jersey: Camden, New Brunswick, Newark, and Trenton.

Data Collection

Participant Data

Participant data were collected using a telephone survey from households in four cities in New Jersey: Camden, New Brunswick, Newark, and Trenton. Participating household data were collected in two panels, and each panel had two rounds of data collection. Panel 1, round 1 data were collected from June 2009 to April 2010 and Panel 2, round 1 data were collected from April to August 2014. Panel 1 collected data from 500 households in Camden, 208 in New Brunswick, 400 in Trenton, and 400 in Newark for a total of 1,408 households. Panel 2 collected data from 199 households in Camden, 62 in New Brunswick, 160 in Trenton, and 382 households in Newark for a total of 803 households. Combined this provides data on 2,211 participants in four cities.

Phone numbers for the telephone survey for Panel 1 were chosen from a random-digit-dial sample using a list of landline household telephone numbers within the geographical areas of the five cities. Households could participate if they had at least one child between the ages of 3 to 18. The respondent of the survey must have been 18 years

or older, responsible for most of the food purchasing decisions for the household, and related to the child through marriage or a blood relative. The respondent answered questions about him/herself as well as about the child. If more than one child lived in the home, one child was randomly selected to be the 'focus child' for the survey. Up to 22 call attempts were made for each qualifying household. The survey was completed in either English or Spanish and participants were given $10 for their time. The average time to complete the survey was 36 minutes. The response rate for Panel 1, round 1 was 49%.

Phone numbers for the telephone survey for Panel 2 were chosen using a multi-frame landline and cell phone sampling method within the geographical areas of the four cities. Requirements were the same as Panel 1, except the house must have had a child between the ages of 3 to 15. Up to 23 call attempts were made for each qualifying household. The survey was completed in either English or Spanish and participants were given $25 for their time. The survey took on average 30 minutes to complete. Approximately 36% of respondents were from a cell phone number and the remaining were from a landline. The overall response rate was 36%.

The survey included sections on demographics, self-reported height/weight, health status, perceived food environment, perceived physical activity environment, child health behaviors, adult health behaviors, health care coverage, employment, and income. The survey items were tested prior to use and were adapted from previously validated surveys and research studies.[134-136]

Food Environment Data

Food environment data were collected and classified according to previously established protocol.[137] Data on food retail stores and restaurants were purchased from InfoUSA[138] and Nielsen[139] in 2008, 2012, 2013, 2014, and 2015. The food outlet list was limited to each city in the study, as well as stores within a one-mile radius of the city limits. The food outlet lists were then cleaned for duplicates and non-food stores (i.e. liquor stores). Potentially incorrect addresses were determined by plotting the location of each establishment using satellite imagery provided by WMS Service to visually analyze businesses located in housing subdivisions, apartment complexes, or other non-business locations.[140] Questionable addresses were then corrected or verified using street view in Google Maps.

Retail stores were classified based on previously published protocol,[137] including by sales volume of the store, their North American Industry Classification System (NAICS) code, and availability of healthy foods. Stores that had a NAICS code of convenience store or grocery store and had yearly sales volume under $1 million were automatically classified as a convenience store. Stores that had a NAICS code of convenience store or grocery store and had sales volume over $1 million were classified based on the number of checkouts and the availability of specific healthy food items: at least five different types of fruits, at least five different types of vegetables, 1% or fat free milk, and fresh or frozen meat. Small grocery stores were classified based on, sales of $1-2 million, being a small chain or non-chain stores, sell at least three of the four healthy food items, and had two to three checkouts.[29,137,141] Supermarkets were classified based on sales over $2 million, part of a corporate supermarket chain, offering all four of the healthy food items, and having four or more checkouts.[29,137,142] Meat markets and fruit

and vegetable markets were classified as such if the store primarily engaged in retailing the specialized food items (meat or produce).[137] If the meat market also offered three of the four healthy food items, they were classified as a meat market+small grocery.

Restaurants in which customers always had to pay for their meal before receiving their food were classified as limited service while restaurants that had customers pay for food after receiving their meal were classified as full service.[137,143] Restaurants that had certain food items in their name, such as chicken, burrito, pizza, or deli, were automatically classified as limited service.[144] The exception to this was Chinese restaurants, which were all classified as limited service due to prior research showing that inner-city Chinese restaurants are primarily limited service and also provide a large number of offerings that are high in calories and fat.[137]

A list of WIC-participating stores in New Jersey was acquired from the New Jersey Department of Health in 2016 for years 2009, 2012, 2013, 2014, and 2015. This list was then limited to stores within a 1 mile radius of the four cities in the study. Stores already listed in the retail food data file were flagged as being a WIC store (1=WIC store, 0=Not WIC). WIC-participating stores not in the retail food data file were added to the database as a WIC store only. Given the historical nature of the WIC store data, no further classification could be completed (supermarket, convenience store, etc.).

Proximity of food outlets to participant's homes were determined by GIS mapping using Esri ArcMap with Network Analyst (version 10.3.1) using network walking distance from door to door. A custom road/path network was built for each year to exclude highways but include parks and pathways.

Measures

For a summary of all variables, see Table 3-1.

Outcome Variables

Dietary intake data was determined by frequency-based questions. Survey questions were adapted from BRFSS and 2009-2010 NHANES.[145,146] Dietary questions were primed with the statement, "The next few questions are about different kinds of foods you ate or drank during the past month. Your best guess is fine. You can tell me number of times per day, per week, or per month."

Frequency of fruit consumption was determined by the question, "Not counting juice, how often did you eat fruit? Count fresh, frozen, or canned fruit." Responses could include by day, by week, or by month. If the respondent said daily, they were asked, "How many times per day." Frequency was then computed by day.

Total frequency of vegetable consumption was determined by combining the results from four different questions on salad, potato, bean, and other vegetable consumption. Frequency of salad consumption was determined by the question, "How often did you eat a green leafy or lettuce salad, with or without other vegetables." Frequency of potato consumption was determined by the question, "Not including French fries or other fried potatoes, how often did you eat any other kind of potatoes such as baked, boiled, mashed potatoes, or potato salad? You can tell me number of times per day, per week or per month." Frequency of bean consumption was captured by, "How often did you eat cooked or canned dried beans, such as refried beans, baked beans, bean soup, tofu, or lentils?" Lastly, other vegetable consumption frequency were captured by the question, "Not including what you just told me about, how often did you eat other vegetables such as tomatoes, green beans, carrots, corn, cooked greens, sweet potatoes,

broccoli, or any other kinds of vegetables?" Frequency of vegetable consumption was then computed by day.

Frequency of sugar sweetened beverage consumption was determined by combining the results of consumption of fruit-flavored drinks with regular soda consumption. Frequency of fruit-flavored drink consumption was determined by the question, "How often did you drink fruit flavored drinks such as lemonade, Sunny Delight, Kool-Aid, Gatorade, or sweet iced teas? Do not include 100% fruit juice." Frequency of regular soda consumption was asked as, "How often did you drink regular carbonated soda or soft drinks such as coke, Pepsi, or 7-up? Do not include diet drinks. You can tell me number of times per day, per week or per month." Frequency of sugar sweetened beverage consumption was then computed by day.

Frequency of fast food consumption was determined by the question, "How often did you eat at a fast food restaurant, deli, pizza, burger, taco or chicken place where you pay before you eat?" Responses could be given by day, week, or month. Answers were then computed to be by week.

Key Exposure Variables

The community food environment variables include the distance to, the presence of, and count of the following types of food outlets: supermarket, convenience store, small grocery, WIC-participating store, and limited service restaurant. Small grocery is a composite variable including small grocery stores, fruit and vegetable markets, and meat market+small grocery. Addresses for each food outlet were geocoded and proximities to each participating household were measured for each food outlet by roadway network miles. The presence of each food outlet was computed as 1=yes/0=no for the following

proximities: ¼ mile, 1/2 mile and 1 mile variables. Lastly, the total count of stores within these three radii were determined and saved as a separate counts variable for each store type.

Health care provider's advice to lose weight was determined by the survey question, "In the past 12 months, has a doctor, nurse, or other health professional given you advice about your weight?" Responses categories included, "yes, lose weight", "yes, gain weight", "yes, maintain weight", "no advice given about weight", "don't know/not sure", or refusal to answer. Those who responded, "yes, lose weight" were coded as receiving advice to lose weight while those who responded "no advice given about weight" were coded as not receiving advice. Given the analysis on doctor's advice to lose weight was completed with overweight and obese respondents only, those who responded with "yes, gain weight" or "yes, maintain weight" were dropped from the sample.

Participation in the SNAP program was determined by the question "Did anyone in your family living there receive food stamps in 2008/2013?" If needed, the follow-up statement was given, "Food Stamps are also referred to as SNAP (Supplemental Nutrition Assistance Program) or as having an EBT card (Electronic Benefits Transfer.)"

WIC participation was determined by the question, "Did anyone in your family living there receive WIC in 2008/2013?" If needed, the follow-up statement was provided, "WIC=Special Supplemental Nutrition Program for Woman, Infants and Children." Responses could include "yes", "no", "don't know", or refusal to answer.

Covariates

Body Mass Index was calculated from self-reported height and weight. Height was captured by the question, "How tall are you without shoes?" while weight was asked,

"How much do you weigh now without shoes?" Overweight was categorized as a body mass index (BMI, kg/m^2) of 25.0–29.9, obesity was categorized as a BMI of 30.0–39.9, and extreme obesity was categorized as a BMI of ≥40.0.[147]

Race/ethnicity was determined by the question, "What is your race?" Responses could include "Black/African American," "White," "American Indian/Native American/Aleutian or Eskimo," "Asian/Pacific Islander," "Hispanic," or "Other." Responses were then categorized into, "Non-Hispanic White," "Non-Hispanic Black," "Hispanic," and other races were categorized into "Other."

Education level was determined by asking the question, "What is the highest grade or level of school that you have completed?" Responses could include, "8th grade or less", "9th to 11^{th}", "12th grade, GED or High School Diploma", "Some Voc/Tech/Business/Trade School", "Some Voc/Tech/Business/Trade School Certificate or Diploma", "Some College/No Degree", "Associate's Degree", "Bachelor's Degree", "Some Graduate/Professional School/No Degree", "Graduate/Professional Degree", "Don't know", or refusal to answer. These responses were then categorized into the following categories, "Less than high school", "High school or Equivalent", "Some College", "Completed college", or "Unknown."

Health insurance status was determined by the survey question, "Do you have some form of health insurance or health care coverage, or not?" If the participant responded yes, they were asked, "Are you mainly covered by Medicare, Medicaid, NJ FamilyCare, insurance through a current or former job or other private insurance, or do you have coverage from some other source?" Responses categories included, "Medicare",

"Medicaid or NJ Family Care", "Employer", "Private", "Other", "Uninsured", or "Don't know/refusal to answer."

Income was asked as, "During 2008/2013, what was your family's total income from all sources before taxes and other deductions?" Answers could be given as annually, weekly, biweekly, monthly, or bimonthly. Income was then converted to percent of the Federal Poverty Level (FPL) due to its consideration of household size.

General health status was determined by the survey question "Would you say your health is . . . ," and possible responses were "excellent", "very good", "good", "fair", or "poor". Respondents could also say, "don't know" or refuse to answer. Responses of excellent and very good were combined into a single group, excellent/very good, as were responses of fair and poor into fair/poor.

Food security was determined by the question, "Which one of the following statements best describes the food eaten by your family? Do you have…" with possible responses of "Enough food to eat", "Sometimes not enough to eat", or "Often not enough to eat?" Participants could also say they "Don't know" or refuse to answer.

Table 3-1: List of all variables, their definition, and type

Variable	Definition	Type
Fruit Consumption	Frequency of consuming fruit, excluding fruit juice, in one day	Continuous
Vegetable Consumption	Frequency of consuming all vegetables in one day	Continuous
Salad Consumption	Frequency of consuming salad in one day	Continuous
SSB Consumption	Frequency of consuming regular soda and sweetened fruit drinks in one day	Continuous
Soda Consumption	Frequency of consuming regular soda in one day	Continuous
Fruit Drink Consumption	Frequency of consuming	Continuous

	sweetened fruit drinks in one day	
Fast Food Consumption	Frequency of consuming fast food over one week	Continuous
Count of Food Outlet	The number of a specific food outlet within a pre-defined radius	Continuous
Presence of Food Outlet	Presence or absence of a specific food outlet within a pre-defined radius	Categorical
HCP Advice	Did participant receive advice to lose weight from HCP	Categorical
SNAP Participation	Household participation in the SNAP program	Categorical
WIC Participation	Household participation in the WIC Program	Categorical
Age	Age of the participant	Continuous, grouped into categories
Gender	Gender of the participant	Categorical
BMI	BMI, as calculated by height and weight of participant	Continuous, grouped into categories
Race	Race or ethnicity of the participant	Categorical
Education	Educational level achieved by participant	Categorical
Insurance	Insurance status and type by participant	Categorical
Income	Household income as a ratio of the Federal Poverty Level	Continuous, grouped into categories (varies by study)
General Health Status	Health status of participant	Categorical
Food Security	Food security status of household	Categorical
Panel	Panel/year of data collection	Categorical
City of Residence	City in which the participant lived	Categorical
SSB=Sugar Sweetened Beverages; HCP=Health Care Provider; SNAP=Supplemental Nutrition Assistance Program; WIC= Special Supplemental Nutrition Program for Women, Infants, and Children; BMI=Body Mass Index		

Analysis

Participant data were limited to the adult respondent only. For each research question, descriptive analyses were conducted on all variables. Chi-squared analysis was used to examine the distribution of categorical variables. Spearman's correlation was run on all covariates to test for multicollinearity. Any variable used in analysis that had a missing value (i.e. the participant responded with "don't know" or refused to answer) was dropped from the analyses.

Research Question 1

To examine how the community food environment moderates the association between the interpersonal layer of the SEM, as represented by health care provider's advice to lose weight, and four dietary behaviors: fruit and vegetable consumption, fast food intake, and sugar sweetened beverage intake in an overweight and obese sample.

Analysis for RQ1 was limited to 1,427 overweight and obese participants, as defined as a BMI of 25 or greater. Model fit testing based on examination of Akaike's information criterion (AIC) revealed that gamma regression with logarithmic link function had the best fit due to the dietary variables' positively skewed distribution. All dietary behaviors were examined.

The covariates age, gender, and race/ethnicity were automatically included in the multivariate model based on the significant literature showing the relationship between these factors and eating behaviors. City of residence and panel were also automatically included to adjust for the participant's location and year of data collection. Other possible covariates, including BMI, income, education, general health status, and insurance status, were tested and included in the multivariate models based on bivariate associations of

$p<0.10$. These covariates were chosen based on previous research that shows an association with doctor's advice to lose weight or dietary behaviors.

Community food environment variables were first examined for variability. A ¼ mile radius was used for LSR and convenience stores, as there was limited variability in distribution of these food outlets beyond a ¼ mile radius, with 95% of households having a LSR and 97% having a convenience store within a ½ mile of home. Conversely, a ½ mile radius was used for small grocery stores and supermarkets, as there was limited variability in the distribution of these outlets within ¼ mile, with only 7% having a small grocery store and 13% having a supermarket in the ¼ mile radius. There were no significant differences in results when using presence/absence or count of food outlets, so presence/absence was used to be consistent with previous research examining the association with weight status of children using these data.[148] To test for interaction, an interaction term (HCP advice##presence of food outlet) was included in the multivariable regression models and then separate, stratified models were run by outlet.

Research Question #2

To examine how the food environment moderates the association between the policy layer of the Social Ecological Model, as represented by participation in the Supplemental Nutrition Assistance Program (SNAP), and four dietary behaviors: fruit and vegetable consumption, fast food intake, and sugar sweetened beverage intake.

Participants in RQ2 was limited to 983 SNAP participants and income-eligible non-SNAP participants, as determined by an income as <130% FPL. Model fit testing based on examination of Akaike's information criterion (AIC) revealed that gamma regression with a logarithmic link function had the best fit. In this study sample, the

distributions of the dietary behaviors were positively skewed. All dietary behaviors were examined.

The covariates age, gender, and race/ethnicity were automatically included in the multivariate model based on the significant literature showing the relationship between these factors and eating behaviors. City of residence and panel were also automatically included to adjust for the participant's location and year of data collection. Other possible covariates, including BMI, income, education, food security, general health status, and WIC participation, were tested and included in the multivariate models based on bivariate associations of $p<0.10$. These covariates were chosen based on previous research that showed an association with SNAP participation or dietary behaviors.

Community food environment variables were first examined for variability. In the four cities used in analysis in this study, there were more LSR and convenience stores near respondent's homes and fewer small grocery stores and supermarkets. A ¼ mile radius was used for LSR and convenience stores, as 97% of households had an LSR and 99% had a convenience store within ½ mile. A ½ mile radius was used for small grocery stores and supermarkets, as only 8% of households had a supermarket and 16% had a small grocery within ¼ mile. There were no significant differences in results when using presence/absence or count of food outlets, so presence/absence was used to be consistent with previous research examining the association with weight status of children using these data.[148] To test for interaction, an interaction term (SNAP participation##presence of food outlet) was included in the multivariable model and then separate, stratified analysis was used to determine the differences in associations between SNAP participation and eating behaviors by food outlets.

Research Question #3

To examine how the association between the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program, representative of the policy layer of the SEM, and fruit and vegetable consumption changed across years, and if the food environment moderates this relationship.

Participants were limited to 420 adults that participated in WIC in Panel 1 or Panel 2. Negative binomial regression was used based on the dietary variables' distributes were skewed and had a large spread with excess zeroes. Only fruit and vegetable consumption behaviors were examined.

The covariates age, gender, and race/ethnicity were automatically included in the multivariate model based on the significant literature showing the relationship between these factors and eating behaviors. City of residence was also automatically included to adjust for the participant's location. BMI, income, education, food security, general health status, and SNAP participation were tested as possible covariates and included in the multivariate models based on bivariate associations of $p<0.10$. These covariates were chosen based on previous research that showed an association with WIC participation or dietary behaviors.

Community food environment variables were first examined for variability. Preliminary analyses revealed the distribution of food outlets varied by type of outlet. WIC-authorized stores, convenience stores, and LSR were located closer to participant's homes while supermarkets and small grocery stores were located farther from participant's homes. A ½ mile radius was used for supermarkets and small grocery stores due to limited variability within a ¼ mile radius; only 17.6% of WIC participants had a

small grocery and 8.5% had a supermarket within ¼ mile. On the other hand, a ¼ mile radius was used for WIC stores, convenience stores, and limited service restaurants due to limited variability beyond a ¼ mile radius; 88.3% of WIC participants had a WIC store, 97.2% had an LSR, and 98.1% had a convenience store within a ½ mile radius. There were no significant differences in results when using presence/absence or count of food outlets, so presence/absence was used to be consistent with previous research examining the association with weight status of children using these data.[148] To test for an interaction, an interaction term (panel##presence of food outlet) was included in the multivariable regression models. To determine differences in association between fruit and vegetable consumption and participant panel (date of data collection) by the community food environment, stratified analyses were conducted by food outlet.

CHAPTER 4

THE INFLUENCE OF THE COMMUNITY FOOD ENVIRONMENT ON THE ASSOCIATION BETWEEN HEALTH CARE PROVIDER ADVICE TO LOSE WEIGHT AND EATING BEHAVIORS

Abstract

Introduction: Only 47% of obese patients receive weight loss advice from their health care provider. Patients who receive weight loss advice from their health care provider are more likely to eat healthy. The food environment has also previously been shown to affect eating behaviors and may be a potential moderator of the effectiveness of weight loss advice on influencing eating behaviors.

Methods: Participant data were obtained from a household telephone survey of 2,211 adults in 4 cities in New Jersey from two cross-sectional panels in 2009-10 and 2014. Community food data were purchased from InfoUSA and Nielsen and classified according to previously established protocol. Analyses presented were limited to 1,427 overweight and obese participants. Stratified gamma regression analysis determined the differences in the association between receiving advice to lose weight and eating behaviors by community food environment.

Results: Stratified analyses revealed that receiving advice to lose weight from a health care provider was associated with a decrease in consumption of total sugar sweetened beverages, soda, and sweetened fruit drinks when participants lived near a small grocery store, or far from a supermarket, limited service restaurant, or convenience store. There was no association between receiving weight loss advice and sugar sweetened beverage

consumption when participants lived near supermarkets, limited service restaurants, or convenience stores.

Discussion: More work is needed to understand moderating factors that influence the effectiveness of professional weight loss advice, and possible environmental strategies that assist in weight loss advice being beneficial.

Introduction

Overweight and obesity (OW/OB) continues to be a public health concern in adults, especially among low-income and minority populations. From 2011-2014, 68.5% of white adults were OW/OB compared to 76.3% of non-Hispanic black adults and 78.4% of Hispanic adults.[1] Given the high prevalence of obesity, the U.S. Preventive Services Task Force recommends that all adult patients be screened for obesity by their health care provider (HCP) and offer the appropriate treatment as needed.[2]

Despite these national guidelines, only 47% of obese patients receive weight loss advice from their HCP.[3] Patients who receive weight loss advice from their HCP are more likely to eat less fat and calories,[4,5] and eat more salad and fruit.[6] However, not all who receive advice from their HCP change their eating behavior.[7] Research on the factors influencing the effectiveness of HCP weight loss advice have focused on the quality of counseling,[8] but have not included patient-centered factors.

The community food environment may be a potential moderator of the effectiveness of HCP weight loss advice on influencing eating behaviors. The food environment has previously been shown to affect eating behaviors. Those who live near a supermarket or grocery store eat more fruit and vegetables,[9,10] while those who live near fast food restaurants and convenience stores drink more sugar sweetened beverages (SSB).[11]

Using data from a low-income, high minority OW/OB sample, this study explores how the community food environment moderates the relationship between receiving HCP advice to lose weight and eating behaviors, potentially explaining why some patients

improve their eating behaviors after receipt of weight loss advice while other patients do not. There are two hypotheses. One, the association between receiving HCP advice to lose weight and participant frequency of fruit and vegetable consumption will be stronger among those who live closer to healthy food outlets, compared to those who do not live close to healthy food outlets. Two, the association between HCP advice to lose weight and sugar sweetened beverage and fast food consumption will be weaker among those who live closer to unhealthy food outlets, compared to those who do not live near unhealthy food outlets.

Methods

Participant Data

Participant data were obtained from a household telephone survey of 2,211 adults in 4 cities in New Jersey: Newark, New Brunswick, Trenton, and Camden. The survey was completed with the adult who made most of the food shopping decisions for their household and had at least one child between the ages of 3-18 years. Survey data were collected in two cross-sectional waves: 1,408 adults from 2008-10 and 803 adults in 2014. The phone survey was conducted in both English and Spanish, and included questions on demographics, food and physical activity behaviors, health status, and employment status.

Study Sample

Analysis was limited to 1,427 OW/OB adults from the two cohorts who were not missing any outcome or explanatory variables. Participants who were normal weight, underweight, or pregnant (n=518) were dropped as these participants would not need weight loss advice. There were 266 participants that had one or more missing outcome or

explanatory variables and were dropped from the sample. Using National Heart, Lung, and Blood Institute guidelines,[12] overweight was categorized as a body mass index (BMI) of 25–29.9 kg/m^2, obesity was categorized as a BMI of 30-39.9 kg/m^2, and extreme obesity was a BMI of ≥40 kg/m^2.

Outcome Variables

Four food groups were chosen as outcome variables based on their relationship with the community food environment: fruits, vegetables, SSB, and fast food. Consumption was determined by frequency-based questions adapted from the Behavior Risk Factor Surveillance Survey and 2009-10 National Health and Nutrition Examination Survey.[13,14] Before asking the dietary consumption questions, survey respondents were told, "The next few questions are about different kinds of foods you ate or drank during the past month. Your best guess is fine. You can tell me number of times per day, per week, or per month." Frequency of fruit consumption was attained by the question, "Not counting juice, how often did you eat fruit? Count fresh, frozen, or canned fruit." Total vegetable consumption was gathered by four questions, "How often did you eat a green leafy or lettuce salad, with or without other vegetables," "Not including French fried or other fried potatoes, how often did you eat any other kind of potatoes such as baked, boiled, mashed potatoes, or potato salad?" "How often did you eat cooked or canned dried beans, such as refried beans, baked beans, bean soup, tofu, or lentils?" and "Not including what you just told me about, how often did you eat other vegetables such as tomatoes, green beans, carrots, corn, cooked greens, sweet potatoes, broccoli, or any other kinds of vegetables?" Salad was also analyzed separately from total vegetable consumption. Fast food consumption was gathered by the question, "How often did you

eat at a fast food restaurant, deli, pizza, burger, taco or chicken place where you pay before you eat?" SSB consumption was gathered by the following two questions, "How often did you drink fruit flavored drinks such as lemonade, Sunny Delight, Kool-Aid, Gatorade, or sweet iced teas? Do not include 100% fruit juice," and "How often did you drink regular carbonated soda or soft drinks such as coke, Pepsi, or 7-up? Do not include diet drinks. You can tell me number of times per day, per week or per month." Consumption of fruits, vegetables, and SSB were calculated as frequency (number of times) per day while fast food consumption was calculated as frequency per week. Frequency of consumption of SSB was a composite variable that included frequency of consuming sweetened fruit drinks and regular soda. Sweetened fruit drinks and regular soda were also included in analyses separately due to their variation in consumption patterns among sub-populations of the sample and by food outlet.[15,16]

Explanatory Variables

Demographic variables, including age, gender, race/ethnicity, education, height, and weight, were self-reported by participants in response to questions from the telephone survey. Race/ethnicity was determined by the question, "What is your race?" Responses were then categorized into, "Non-Hispanic White," "Non-Hispanic Black," "Hispanic," and other races were categorized into "Other." The participant's education level was determined by the question, "What is the highest grade or level of school that you have completed?" Responses were then categorized into, "less than high school", "high school or equivalent," "some college," or "college graduate." General health status was determined by the question "Would you say your health is…," with possible responses including "excellent", "very good", "good", "fair", or "poor". Responses of

excellent and very good were combined into a single group, excellent/very good and responses of fair and poor were combined into fair/poor.

Receiving HCP's advice to lose weight was determined by the question, "In the past 12 months, has a doctor, nurse, or other health professional given you advice about your weight?" Responses could include "yes, lose weight", "yes, gain weight", "yes, maintain weight", "no advice given about weight", "don't know/not sure", or refusal to answer. Participants who responded, "yes, lose weight" were coded as 1 for HCP's advice to lose weight while those who received no advice were coded as 0. Participants who responded, "yes, gain weight" (n=7) or "yes, maintain weight" (n=43) were dropped from the sample due to conflicting information with their OW/OB status.

Community food data were purchased from InfoUSA[17] and Nielsen[18] in 2008, for panel 1, and 2014, for panel 2. Food outlets were classified according to previously established protocol, which included purchasing a database of food outlets and further classifying the stores according to the items sold in stores, the store sales volume, and North American Industry Classification System (NAICS) code.[19] Outlets were classified into one of the following 8 types: supermarket, small grocery store, convenience store, fruit and vegetable market, meat market, meat market+small grocery, full service restaurant, or limited service restaurant (LSR). For this study, only four outlets were used in analysis: supermarket, small grocery store, convenience store, or LSR. Small grocery stores, fruit and vegetable markets, and meat market+small grocery stores were combined into one composite small grocery store variable.

Proximity of food outlets to participant's homes were determined by GIS mapping using Esri ArcMap with Network Analyst (version 10.3.1) using network

walking distance from door to door. A custom road/path network was built for each year to exclude highways but include parks and pathways. Preliminary analysis revealed that the distribution of food outlets within the community varied by type of outlet; unhealthy food outlets were closer to participant's homes while healthy food outlets were farther from participant's homes. A ¼ mile radius was used for LSR and convenience stores, as there was limited variability in distribution of these food outlets beyond a ¼ mile radius, with 95% of households having a LSR and 97% having a convenience store within a ½ mile of home. Conversely, a ½ mile radius was used for small grocery stores and supermarkets, as there was limited variability in the distribution of these outlets within ¼ mile, with only 7% having a small grocery store and 13% having a supermarket in the ¼ mile radius.

Statistical Analysis

Descriptive analyses were conducted using Chi-squared tests for categorical variables and t-tests for continuous variables.

Multivariable analysis: Model fit testing based on examination of Akaike's information criterion (AIC) revealed that gamma regression with logarithmic link function had the best fit due to the dietary variables' positively skewed distribution. The antilogarithm of the regression coefficient, e^b, for gamma regression represents the proportional differences in the outcome associated with a 1-unit increase in the independent variable. In this analysis, e^b represents the proportional difference in frequency of food or beverage consumption with the receipt of HCP weight loss advice, compared to not receiving weight loss advice. For example, an e^b value of 1.25 for a food item would mean a 25% higher frequency of consumption for that food item for those

who received HCP advice to lose weight compared to those who did not receive weight loss advice. Inclusion of variables in the multivariable model were determined by bivariate associations of $p<0.10$. However, this inclusion criterion was not used for the variables age, gender, race, city of residence, and panel, which were included in all models.

Interaction and stratified analyses: To test for interaction, an interaction term (HCP advice##presence of food outlet) was included in the multivariable regression models and then separate, stratified models were run for presence or absence of specific outlets. There were no significant differences in results when using presence/absence or count of food outlets, so presence/absence was used to be consistent with previous research examining the association with weight status of children using these data.[20] To determine differences in the association between HCP's advice to lose weight and eating behaviors by community food environment, analyses were stratified food outlet. All analyses were conducted in Stata (version 13.1). Individual associations were considered significant at $p<0.05$ and interactions were considered significant at $p<0.10$.

Results

Of the 1,427 OW/OB respondents, 82% were female, 59% were non-Hispanic black, and 56% were between the ages of 35 to 54 years (Table 4-1). There were significant differences in who received HCP's advice by age, race/ethnicity, BMI, health status, and year of data collection. Of participants ages ≥55 years, 45% received advice compared to 30% of participants ages 18-34 years. A higher percentage of black and Hispanic participants (39% for both) received HCP advice compared to white participants (25%). A greater percentage of participants who were obese (BMI=30-39.9) or extremely

obese (BMI≥40) received HCP advice to lose weight compared to those who were overweight (44% and 67% vs. 23%). Of the participants from Panel 2 (2014), 44% received advice compared to only 34% of participants from Panel 1 (2009-10).

Table 4-1: Demographic characteristics and eating behaviors by receipt of advice from a health care provider to lose weight. Cross-sectional data from overweight and obese individuals collected from four New Jersey cities in 2009-10 and 2014 (n=1,427).

	All OW/OB Respondents (n=1,427)	**No HCP's Advice** (n=892)	**HCP's Advice** (n=535)	**P-value for difference by receipt of advice**
	n (%)	n (%)	n (%)	
Age				<0.001
18-34	437 (30.6%)	308 (70.5%)	129 (29.5%)	
35-54	800 (56.1%)	480 (60%)	320 (40%)	
55+	190 (13.3%)	104 (54.7%)	86 (45.3%)	
Gender				<0.001
Male	262 (18.4%)	193 (73.7%)	69 (26.3%)	
Female	1,165 (81.6%)	699 (60%)	466 (40%)	
Race/ethnicity				0.01
Non-Hispanic white	72 (5.1%)	54 (75%)	18 (25%)	
Non-Hispanic black	848 (59.4%)	520 (61.3%)	328 (38.7%)	
Hispanic	480 (33.6%)	295 (61.5%)	185 (38.5%)	
Other	27 (1.9%)	23 (85.2%)	4 (14.8%)	
BMI category				<0.001
25-29.9	617 (43.2%)	474 (76.8%)	143 (23.2%)	
30-39.9	649 (45.5%)	364 (56.1%)	285 (43.9%)	
≥40	161 (11.3%)	54 (33.5%)	107 (66.5%)	
Education				0.62
Less than high school	243 (17%)	153 (63%)	90 (37%)	
High school or equivalent	591 (41.4%)	369 (62.4%)	222 (37.6%)	
Some college	398 (27.9%)	241 (60.6%)	157 (39.5%)	
College Graduate	195 (13.7%)	129 (66.2%)	66 (33.9%)	
Poverty status				0.61
≤100% poverty level	503 (35.2%)	308 (61.2%)	195 (38.8%)	
100-199% poverty level	472 (33.1%)	292 (61.9%)	180 (38.1%)	
200-399% poverty level	318 (22.3%)	202 (63.5%)	116 (36.5%)	
≥400% poverty level	134 (9.4%)	90 (67.2%)	44 (32.8%)	
General Health Status				<0.001

Excellent/Very Good	556 (39%)	401 (72.1%)	155 (27.9%)	
Good	526 (36.9%)	313 (59.5%)	213 (40.5%)	
Fair/Poor	345 (24.2%)	178 (51.6%)	167 (48.4%)	
Food Outlet Environment				
Small Healthy Outlet				0.89
Absence – ½ mile	878 (61.5%)	550 (62.6%)	328 (37.4%)	
Presence – ½ mile	549 (38.5%)	342 (62.3%)	207 (37.7%)	
Supermarket				0.70
Absence – ½ mile	985 (69%)	619 (62.8%)	366 (37.2%)	
Presence – ½ mile	442 (31%)	273 (61.8%)	169 (38.2%)	
Convenience Store				0.48
Absence – ¼ mile	306 (21.4%)	186 (60.8%)	120 (39.2%)	
Presence – ¼ mile	1,121 (78.6%)	706 (63%)	415 (37%)	
Limited Service Restaurant				0.07
Absence – ¼ mile	469 (32.9%)	309 (65.9%)	160 (34.1%)	
Presence – ¼ mile	958 (67.1%)	583 (60.9%)	375 (39.1%)	
Panel				<0.001
1 (2009-10)	895 (62.7%)	593 (66.3%)	302 (33.7%)	
2 (2014)	532 (37.3%)	299 (56.2%)	233 (43.8%)	
City of Residence				0.70
Camden	421 (29.5%)	272 (64.6%)	149 (35.4%)	
Newark	498 (34.9%)	303 (60.8%)	195 (39.2%)	
New Brunswick	162 (11.4%)	100 (61.7%)	62 (38.3%)	
Trenton	346 (24.3%)	217 (62.7%)	129 (37.3%)	
	Mean (SD)	Mean (SD)	Mean (SD)	p-value
Fruit – all (daily)	1.03 (1.21)	1.00 (1.2)	1.07 (1.23)	0.26
Vegetables - all (daily)	2.19 (1.57)	2.14 (1.55)	2.27 (1.59)	0.12
Salad (daily)	0.73 (0.88)	0.68 (0.79)	0.81 (1.00)	0.01
Fast Food (weekly)	1.00 (1.49)	1.05 (1.64)	0.92 (1.19)	0.12
Sugar Sweetened Beverages – all (daily)	1.12 (1.58)	1.16 (1.56)	1.03 (1.61)	0.13
Soda (daily)	0.51 (1.07)	0.55 (1.06)	0.45 (1.07)	0.09
Fruit Drinks (daily)	0.60 (1.00)	0.62 (0.96)	0.58 (1.08)	0.56

HCP=Health care provider; OW/OB=overweight and obese

Note: Chi-squared analysis used to determine p-value of difference among groups for categorical variables and t-test used to determine difference in eating behaviors by HCP's advice to lose weight.

Note: Numbers/percentages for receipt of HCP's advice sum across row to see differences of variables by receipt of advice. Percentages may sum over 100% due to rounding.

In unadjusted analyses, HCP advice to lose weight was associated with a higher mean frequency of daily salad consumption (p=0.01) (Table 4-1). Soda consumption was also lower among those who received advice compared to those who did not receive advice, but this difference was only marginally significant (p=0.09).

Table 4-2 shows associations between key independent variables and outcomes adjusting for age, gender, race/ethnicity, education, general health status, city of residence, BMI, and panel (year of data collection). Receiving HCP advice to lose weight was associated with a 24% lower frequency of consuming soda (p=0.02) and 16% lower frequency of consuming SSB (p=0.03). There was a marginally significant association between HCP advice to lose weight and salad frequency consumption (e^b=1.14; CI: 0.99, 1.30; p=0.06). Although not reaching statistical significance, the presence of a LSR within ¼ mile was associated with higher vegetable and salad consumption frequency (p=0.07). There was also a marginally significant association between presence of a small grocery store within ½ mile and lower SSB consumption (p=0.08). Sensitivity analysis revealed no differences in demographic variables or outcomes when participants with missing variables were included in the models.

Table 4-2: Associations of frequency of consumption of selected food and beverage items with receipt of advice to lose weight from a health care provider (yes/no), and with presence of various food outlets. Cross-sectional data from overweight and obese individuals collected from four New Jersey cities in 2009-10 and 2014 (n=1,427).[ac]

Food and beverage items	**Association with Receiving HCP Advice (vs. no advice)**		**Presence of Small Grocery within ½ mile**		**Presence of Supermarket within ½ mile**		**Presence of Convenience Store within ¼ mile**		**Presence of LSR within ¼ mile**	
	e^b (CI)	p-value	e^b (CI)	p-value	e^b (CI)	p-value	e^b (CI)	p-value	e^b (CI)	p-value
Fruit – all (daily)	1.07 (0.94, 1.22)	0.33	1.04 (0.92, 1.18)	0.56	1.06 (0.92, 1.22)	0.40	0.98 (0.84, 1.13)	0.76	1.02 (0.89, 1.16)	0.81
Vegetables – all (daily)	1.05 (0.97, 1.14)	0.22	0.98 (0.92, 1.08)	0.95	0.95 (0.87, 1.04)	0.25	1.03 (0.93, 1.13)	0.60	1.08 (0.99, 1.17)	0.07
Salad (daily)	1.14 (0.99, 1.30)	0.06	0.98 (0.88, 1.14)	0.97	1.01 (0.87, 1.17)	0.91	1.05 (0.89, 1.23)	0.58	1.14 (0.99, 1.30)	0.07
Fast Food (weekly)	0.96 (0.82, 1.13)	0.65	0.98 (0.85, 1.14)	0.80	1.08 (0.92, 1.27)	0.32	1.09 (0.91, 1.30)	0.34	1.02 (0.88, 1.19)	0.80
Sugar Sweetened Beverages – all (daily)	0.84 (0.72, 0.99)	0.03	0.88 (0.76, 1.01)	0.08	0.99 (0.84, 1.16)	0.89	0.97 (0.81, 1.15)	0.71	1.01 (0.87, 1.17)	0.91
Soda (daily)	0.76 (0.60, 0.96)	0.02	0.89 (0.71, 1.11)	0.31	0.94 (0.75, 1.19)	0.63	1.04 (0.80, 1.35)	0.77	1.04 (0.83, 1.30)	0.76
Fruit Drinks (daily)	0.93 (0.77, 1.12)	0.43	0.87 (0.73, 1.04)	0.13	1.02 (0.84, 1.24)	0.81	0.90 (0.73, 1.11)	0.33	0.99 (0.83, 1.19)	0.95

HCP=Health care provider; LSR=Limited Service Restaurant; e^b = antilogarithm of regression coefficient and represents the proportional difference in frequency of food or beverage consumption with the receipt of weight loss advice vs no advice.

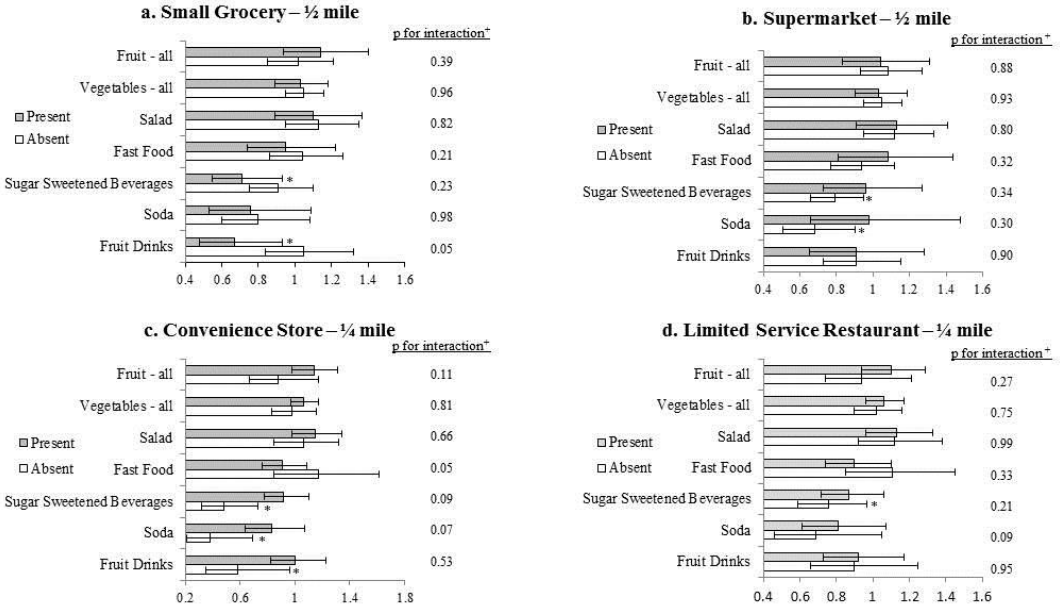
[a] Separate models were run for each food item and each food outlet

[c] Each model used gamma regression and was adjusted for age, gender, race/ethnicity, education, general health status, city of residence, BMI category, and panel (year of data collection).

Stratified analyses (Figure 4-1, complete data shown in Supplementary Tables 4a-d) reveal that the associations between HCP advice to lose weight and beverage consumption varied depending on presence or absence of food outlets. For those who

lived within ½ mile of a small grocery store, receiving HCP advice to lose weight was associated with a 33% lower frequency of fruit drink consumption (e^b=0.67, CI: 0.48, 0.93) and 29% lower frequency of total SSB consumption (e^b=0.71, CI: 0.55, 0.93). There was no association between HCP advice to lose weight and fruit drink and total SSB (e^b=1.05, CI: 0.84, 1.32, e^b=0.91, CI: 0.75, 1.10, respectively) when a small grocery store was absent.

Figure 4-1: Stratified analysis of the association between HCP advice to lose weight and eating behaviors, based on presence or absence of a food outlet, and the significance of the interaction between HCP advice and food outlet presence.



HCP=Health care provider. *p<0.05 for association between health care provider advice and eating behavior, based on specific presence or absence of food outlet.
+p-value from an independent model including interaction between health care provider advice and food outlet presence, fully adjusting for age, gender, race/ethnicity, education, general health status, BMI category, city of residence, and panel (year of collection).

For those who did not have a supermarket within ½ mile of their home, receiving HCP advice to lose weight was associated with a 21% lower frequency of total SSB (e^b=0.79, CI: 0.66, 0.95) and 32% lower frequency of soda consumption (e^b=0.68, CI: 0.51, 0.90). There was no association between HCP advice and total SSB and soda

consumption (e^b=0.96, CI: 0.73, 1.27, e^b=0.98, CI: 0.66, 1.48, respectively) when a supermarket was present within ½ mile.

In participants who did not have a convenience store present within ¼ mile of their homes, receiving HCP advice to lose weight was associated with a 62% lower frequency of total SSB (e^b=0.48, CI: 0.32, 0.73), 72% lower frequency of soda (e^b=0.38, CI: 0.21, 0.69), and 42% lower frequency of fruit drink consumption (e^b=0.58, CI: 0.35, 0.96). There was no association between HCP advice and the consumption of total SSB (e^b=0.92, CI: 0.78, 1.10), soda (e^b=0.83, CI: 0.64, 1.07), or fruit drinks (e^b=1.00, CI: 0.82, 1.23) when a convenience store was present.

Lastly, among participants who did not have a LSR present within ¼ mile of their home, receiving HCP advice to lose weight was associated with a 24% lower total SSB consumption (e^b=0.76, CI: 0.59, 0.97) and 31% lower frequency of soda consumption (e^b=0.69, CI: 0.46, 1.05), although marginally significant. There was no significant association between HCP advice to lose weight and total SSB (e^b=0.87, CI: 0.72, 1.06) or soda (e^b=0.81, CI: 0.61, 1.07) consumption when an LSR was present within ¼ mile of their home.

Discussion

This study was the first to examine how the community food environment influences the relationship between receiving weight loss advice from a HCP and consumption of food and beverages in an OW/OB population. Interaction and stratified analyses revealed that receiving HCP advice to lose weight was associated with a decrease in consumption of total SSB, soda, and sweetened fruit drinks when participants lived near a small grocery store, or far from a supermarket, LSR, or convenience store.

However, when participants lived near supermarkets, LSR, or convenience stores, there was no association between HCP advice and SSB consumption. These results elucidate the role of the community food environment in influencing the effectiveness of receiving HCP weight loss advice.

While past studies that have examined the associations of HCP advice with eating behaviors have been mostly positive, all but one study used participant self-report constructs such as "reduced calories and fat" [4,21] or "modified diet"[7,22] instead of consumption of specific foods. Given the use of abstract constructs compared to specific food items, it is not clear which eating behaviors were changed as part of those constructs. The influence of the community food environment on these constructs is also unclear, as past studies have not examined this association.

Most studies that have analyzed the influence of the community food environment have focused on fruit and vegetable consumption,[9,10,23,24] with only three examining SSB.[11,25,26] Laska et al. found similar results to the current study; there was a significant association between SSB consumption and proximity to food retail outlets and fast food restaurants among adolescents.[11] SSB consumption was 25% and 24% higher when there was a fast food restaurant or convenience store, respectively, within 1,600 m of the adolescent's home. The current study's result of lower SSB consumption when a supermarket was not present also aligns with past research. Gustafson et al. found that those who shopped frequently at a supermarket had a higher odds of consuming SSB.[26] The positive association between supermarkets and SSB consumption may be due to the variety of beverages found within supermarkets. A study in Sao Paulo, Brazil found that adults who lived in a census tract with a greater variety of SSB were more likely to

consume SSB.[25] Another study examined the prices of various food items at both convenience stores and supermarkets and reported that soda was 3 cents lower per ounce at supermarkets compared to convenience stores.[27]

Given there was no association between HCP advice and SSB consumption when participants lived near supermarkets, LSR, or convenience stores, receiving HCP advice to lose weight may not be powerful enough to overcome environmental cues such as in-store marketing and price discounts. However, modifications to the food environment could theoretically enhance the association between HCP advice and healthy eating behaviors rather than null it. In a report by the Center for Disease Control and Prevention, recommended strategies for reducing SSB included limiting access to SSB, creating a cost differential so healthy beverages are less expensive than SSB, limiting the marketing of SSB, and including SSB-related counseling in routine medical care.[28] A study examining the effect of a soda tax in Berkeley, California noted that consumption decreased 21% after the tax was enacted.[29] An intervention that increased the price of soda in a worksite cafeteria resulted in a 26% decrease in soda purchases. When an educational campaign was added, purchases declined another 18%.[30] Using soda taxes or price differentials so that SSB are more expensive than healthy beverages and in-store education on the calories within SSB may help enhance the effects of HCP advice.

There are several strengths to the current study. Participants were mostly low-income and from racial/ethnic minority groups, populations which have a greater risk of obesity and obesity-related illnesses. In addition, the classification process for community food outlets was more robust compared to using database information alone and was based on previously published protocol. Lastly, GIS-mapping was used to determine

proximity to each participant's home rather than grouping participants by census tract, allowing for more precise measurements of presence and absence of food outlets.

This study does have some limitations. The question to capture receipt of weight loss advice from a HCP included a 12-month timeframe, and it is unknown when participants received the advice within that 12-month period. Because both the independent variables and eating behaviors were self-reported, there is possibility for same source bias and underreporting of unhealthy eating behaviors.[31] In addition, while the classification process for food outlets was robust, it was based on purchased data and there is a possibility that some food outlets were missing from the database.[32] Lastly, the data was cross-sectional and therefore is only able to show associations and not cause-effect relationships.

This study highlights the role of the community food environment in shaping eating behaviors and the effectiveness of receiving weight loss advice from a HCP. Receiving HCP weight loss advice is associated with multiple positive eating behaviors, but these beneficial associations are not found when participants lived near supermarkets, LSR, or convenience stores. More work is needed to understand moderating factors that influence the effectiveness of HCP weight loss advice, and possible environmental strategies that assist in HCP weight loss advice being beneficial.

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Supplementary Table 4a: Stratified analysis of association of HCP advice with frequency of consumption of selected food and beverage items for overweight and obese participants by presence or absence of a small grocery store within ½ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	HCP Advice[a]				Interaction[b]
	Small Grocery Absent (n=878)		Small Grocery Present (n=549)		
	e^b (CI)	p-value	e^b (CI)	p-value	p-value
Fruit - all	1.02 (0.85, 1.21)	0.86	1.14 (0.94, 1.40)	0.19	0.39
Vegetables - all	1.05 (0.95, 1.16)	0.36	1.03 (0.89, 1.18)	0.71	0.96
Salad	1.13 (0.95, 1.35)	0.17	1.10 (0.89, 1.37)	0.36	0.82
Fast Food	1.04 (0.86, 1.26)	0.68	0.95 (0.74, 1.22)	0.70	0.21
SSB - Total	0.91 (0.75, 1.10)	0.34	0.71 (0.55, 0.93)	0.01	0.23
Soda	0.80 (0.60, 1.08)	0.15	0.76 (0.53, 1.09)	0.14	0.98
Fruit Drinks	1.05 (0.84, 1.32)	0.67	0.67 (0.48, 0.93)	0.02	0.05

HCP=Health care provider; SSB=Sugar sweetened beverage; e^b = antilogarithm of regression coefficient

[a] Association of HCP advice and eating behavior stratified by presence or absence of a small grocery store within ½ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of data collection)

[b] P-value for independent model including interaction between HCP advice and small grocery presence, also controlling for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of collection)

Supplementary Table 4b: Stratified analysis of association of HCP advice with frequency of consumption of selected food and beverage items for overweight and obese participants by presence or absence of a supermarket within ½ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	HCP Advice[a]				Interaction[b]
	Supermarket Absent (n=985)		Supermarket Present (n=442)		
	e^b	p-value	e^b	p-value	p-value

	(CI)		(CI)		
Fruit - all	1.08 (0.93, 1.27)	0.32	1.04 (0.83, 1.31)	0.73	0.88
Vegetables - all	1.05 (0.95, 1.16)	0.32	1.03 (0.90, 1.19)	0.66	0.93
Salad	1.12 (0.95, 1.33)	0.17	1.13 (0.91, 1.41)	0.28	0.80
Fast Food	0.94 (0.77, 1.12)	0.46	1.08 (0.81, 1.44)	0.60	0.32
SSB - Total	0.79 (0.66, 0.95)	0.01	0.96 (0.73, 1.27)	0.78	0.34
Soda	0.68 (0.51, 0.90)	0.01	0.98 (0.66, 1.48)	0.94	0.30
Fruit Drinks	0.91 (0.73, 1.15)	0.45	0.91 (0.65, 1.28)	0.58	0.90

HCP=Health care provider; SSB=Sugar sweetened beverage; e^b = antilogarithm of regression coefficient

[a] Association of HCP advice and eating behavior stratified by presence or absence of a supermarket within ½ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of data collection)

[b] P-value for independent model including interaction between HCP advice and supermarket presence, also controlling for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of collection)

Supplementary Table 4c: Stratified analysis of association of HCP advice with frequency of consumption of selected food and beverage items for overweight and obese participants by presence or absence of a convenience store within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	HCP Advice[a]				Interaction[b]
	Convenience Store Absent (n=306)		Convenience Store Present (n=1,121)		
	e^b (CI)	p-value	e^b (CI)	p-value	p-value
Fruit - all	0.88 (0.67, 1.17)	0.38	1.14 (0.98, 1.31)	0.09	0.11
Vegetables - all	0.98 (0.83, 1.16)	0.80	1.06 (0.97, 1.17)	0.20	0.81
Salad	1.06 (0.85, 1.32)	0.60	1.15 (0.98, 1.34)	0.08	0.66
Fast Food	1.17 (0.85, 1.61)	0.33	0.91 (0.76, 1.09)	0.30	0.05
SSB -	0.48	0.001	0.92	0.36	0.09

Total	(0.32, 0.73)		(0.78, 1.10)		
Soda	0.38 (0.21, 0.69)	0.001	0.83 (0.64, 1.07)	0.14	0.07
Fruit Drinks	0.58 (0.35, 0.96)	0.04	1.00 (0.82, 1.23)	0.98	0.53

HCP=Health care provider; SSB=Sugar sweetened beverage; e^b = antilogarithm of regression coefficient

[a] Association of HCP advice and eating behavior stratified by presence or absence of a convenience store within ¼ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of data collection)

[b] P-value for independent model including interaction between HCP advice and convenience store presence, also controlling for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of collection)

Supplementary Table 4d: Stratified analysis of association of HCP advice with frequency of consumption of selected food and beverage items for overweight and obese participants by presence or absence of a limited service restaurant within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	HCP Advice[a]				Interaction[b]
	LSR Absent (n=469)		LSR Present (n=958)		
	e^b (CI)	p-value	e^b (CI)	p-value	p-value
Fruit - all	0.94 (0.74, 1.21)	0.64	1.10 (0.94, 1.29)	0.22	0.27
Vegetables - all	1.02 (0.90, 1.16)	0.75	1.06 (0.96, 1.17)	0.26	0.75
Salad	1.12 (0.92, 1.38)	0.26	1.13 (0.96, 1.33)	0.15	0.99
Fast Food	1.11 (0.85, 1.45)	0.46	0.90 (0.74, 1.10)	0.32	0.33
SSB - Total	0.76 (0.59, 0.97)	0.03	0.87 (0.72, 1.06)	0.17	0.21
Soda	0.69 (0.46, 1.05)	0.09	0.81 (0.61, 1.07)	0.14	0.09
Fruit Drinks	0.90 (0.66, 1.25)	0.54	0.92 (0.73, 1.17)	0.51	0.95

HCP=Health care provider; SSB=Sugar sweetened beverage; LSR=Limited Service Restaurant; e^b = antilogarithm of regression coefficient

[a] Association of HCP advice and eating behavior stratified by presence or absence of a limited service restaurant within ¼ mile, using gamma regression adjusting for

age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of data collection)

[b] P-value for independent model including interaction between HCP advice and limited service restaurant presence, also controlling for age, gender, race/ethnicity, education, general health status, BMI, city of residence, and panel (year of collection)

CHAPTER 5

THE INFLUENCE OF THE COMMUNITY FOOD ENVIRONMENT ON THE ASSOCIATION BETWEEN SNAP PARTICIPATION AND EATING BEHAVIORS

Abstract

Introduction: The Supplemental Nutrition Assistance Program (SNAP) is the United States' largest nutrition assistance program for low-income populations and is considered the first defense against hunger. While the SNAP program reduces food insecurity, research varies on the diet quality of program participants compared to income-eligible non-participants. The community food environment is associated with eating behaviors and may be a potential moderator of the association of SNAP participation and eating behaviors.

Methods: Data on respondents were collected from a telephone survey of 2,211 households in four cities in New Jersey. Data were collected from two cross-sectional panels from 2009-10 and 2014. Food outlet data were purchased from commercial sources and classified according to previously published protocol. Analyses were limited to 983 respondents with household incomes below 130% of the Federal Poverty Level. Interaction and stratified analyses using gamma regression determined the differences in the association between SNAP participation and eating behaviors by the presence or absence of food outlets.

Results: Interaction and stratified analyses revealed that SNAP participation was associated with a higher consumption of sugar sweetened beverages when respondents lived close to a small grocery store, supermarket, and limited service restaurant.

Discussion: This study elucidates that the community food environment may play a role in moderating the association between SNAP participation and eating behaviors. While SNAP participation is associated with some unhealthy behaviors, this association only holds true when respondents live in certain food environments.

Introduction

While food insecurity has declined in recent years, it remains a public health issue in the United States. In 2015, an estimated 15.8 million households, 12.7% of the population, were food insecure at least some time during the year.[1] The Supplemental Nutrition Assistance Program (SNAP), formerly known as the Food Stamp Program, is this country's largest nutrition assistance program for low-income populations and is considered the first defense against hunger.[2]

While the SNAP program reduces food insecurity,[3] many studies have found that SNAP participation is associated with unhealthy eating behaviors such as lower fruit and vegetable consumption, higher SSB consumption, and poorer overall diet quality, compared to income-eligible non-participants.[4-6] However, other studies have found no difference between participants and income-eligible non-participants[7,8] and that SNAP participants may even consume more fruit than income-eligible non-participants.[3]

The community food environment may be a factor that influences the eating behaviors of SNAP participants. Past research has shown that living near certain food outlets, such as convenience stores or supermarkets, or restaurants can influence what people eat. Gustafson et al. examined the eating behaviors of SNAP participants and their food environment and found that participants who lived within ½ mile of a farmer's market consumed more fruits, vegetables, grains, and milk.[9] A similar study examined the association of food outlets with macronutrient intakes among SNAP participants and found SNAP participants had a higher consumption of calories and fat when living in counties with multiple gas stations with food marts compared to participants who did not have multiple gas stations.[10] However, these studies did not examine whether these

behaviors were different for income-eligible non-participants. An examination of SNAP-authorized retailers found that only 1/3 of the food outlets sold fresh vegetables and only ¼ sold whole-grain products.[11] SNAP-authorized retailers also score significant lower on healthfulness assessment scales than non-SNAP stores.[12]

The community food environment has been shown to influence the eating behaviors of non-SNAP participants as well. Fruit and vegetable consumption is higher among those who live closer to supermarkets and[13,14] fast food and SSB consumption is higher among those who live near fast food restaurants.[15,16]

Given the mixed results of SNAP participation's association with eating behaviors, as well as the role the food environment plays in shaping eating behaviors, this study aims to examine how the community food environment moderates the relationship between SNAP participation and eating behaviors. There are two hypotheses. One, the association between SNAP participation and participant frequency of fruit and vegetable consumption will be stronger among those who live closer to healthy food outlets, compared to those who do not live close to healthy food outlets. Two, the association between SNAP participation and SSB and fast food consumption will be weaker among those who live closer to unhealthy food outlets, compared to those who do not live near unhealthy food outlets. This study is the first of its kind to examine this potential moderation and the results from this study may help explain the inconsistencies in past research.

Methods

Respondent Data

Data on respondents were collected as part of the New Jersey Child Healthy Study, a longitudinal study examining the role of the food and physical activity environment on children's health. Data were collected from a telephone survey of 2,211 households in New Jersey. Adults were able to complete the phone survey if they had at least one child between the ages of 3-18, made the food shopping decisions for the household and lived in one of the four following cities: Newark, New Brunswick, Trenton, and Camden. The household survey was completed at two different time points, with 1,408 adults completing the survey from 2009-2010 and another 803 adults in 2014. The phone survey included questions on demographics, eating behaviors, physical activity habits, health status, and employment status. Respondents could take the survey in either English or Spanish.

Study Sample

Analysis was limited to 983 respondents with household incomes below 130% of the Federal Poverty Level (FPL) and who were not missing any outcome or explanatory variables. Respondents with household incomes above 130% of the FPL (n=1,161) were dropped as these respondents would not be eligible to participate in SNAP based on household income. There were 67 respondents that had one or more missing variables and were dropped from the sample.

Outcome Variables

Six eating behaviors were chosen for this study, based on their indicators as overall quality of diet and their association with health outcomes: fruit, vegetables, salad, fast food, fruit drinks, and regular soda. Fruit drinks and regular soda were then combined into a total sugar sweetened beverage (SSB) variable, and were also analyzed

separately due to their independent associations with the food environment and with sub-populations of the sample.[17,18] Questions to determine consumption of foods and beverages were prefaced with the statement, "The next few questions are about different kinds of foods you ate or drank during the past month. Your best guess is fine. You can tell me number of times per day, per week, or per month." Frequency of fruit consumption was obtained by the question, "Not counting juice, how often did you eat fruit? Count fresh, frozen, or canned fruit." Total vegetable consumption was a composite of four questions, "How often did you eat a green leafy or lettuce salad, with or without other vegetables," "Not including French fried or other fried potatoes, how often did you eat any other kind of potatoes such as baked, boiled, mashed potatoes, or potato salad?" "How often did you eat cooked or canned dried beans, such as refried beans, baked beans, bean soup, tofu, or lentils?" and "Not including what you just told me about, how often did you eat other vegetables such as tomatoes, green beans, carrots, corn, cooked greens, sweet potatoes, broccoli, or any other kinds of vegetables?" Salad was also analyzed separately from total vegetable consumption. Fast food consumption was obtained by the question, "How often did you eat at a fast food restaurant, deli, pizza, burger, taco or chicken place where you pay before you eat?" SSB consumptions was determined by two questions, "How often did you drink fruit flavored drinks such as lemonade, Sunny Delight, Kool-Aid, Gatorade, or sweet iced teas? Do not include 100% fruit juice," and "How often did you drink regular carbonated soda or soft drinks such as coke, Pepsi, or 7-up? Do not include diet drinks. You can tell me number of times per day, per week or per month." These questions were adapted from the Behavior Risk Factor Surveillance Survey and 2009-10 National Health and Nutrition Examination

Survey.[19,20] Respondents could answer this question by day, week, or month. Fast food consumption was then calculated as number of times per week and all other items were calculated as number of times per day.

Explanatory Variables

Respondent demographic information was collected via the phone survey, which included age, gender, race/ethnicity, education, income, height, and weight. Race/ethnicity was obtained by the question, "What is your race?" Responses were then categorized to, "Non-Hispanic White," "Non-Hispanic Black," "Hispanic," and "Other." Education was determined by the question, "What is the highest grade or level of school that you have completed?" Responses were then categorized into, "less than high school", "high school or equivalent," "some college," or "college graduate." Income was determined by the question, "During 2008/2013, what was your family's total income from all sources, before taxes and other deductions? Include job wages, public assistance, social security, child support, and any other sources of income." Income was then calculated to be a percentage of the Federal Poverty Level to account for household size.

SNAP participation was collected by the question, ""Did anyone in your family living there receive food stamps in 2008/2013?" If needed, the follow-up statement was given, "Food Stamps are also referred to as SNAP (Supplemental Nutrition Assistance Program) or as having an EBT card (Electronic Benefits Transfer)." Participation in Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was determined by the question, "Did anyone in your family living there receive WIC in 2008/2013?" If needed, the follow-up statement was provided, "WIC=Special

Supplemental Nutrition Program for Woman, Infants and Children." Respondents who responded with "don't know" or refused to answer either the SNAP or WIC question were marked as missing and dropped from analysis.

Food outlets were classified based on previously published protocol.[21] A database of food outlets were purchased from InfoUSA[22] and Nielsen[23] in 2008, to align with panel 1, and 2014, to align with panel 2. Outlets were then classified into six retail outlets or two types of restaurants based on the food sold in stores, the store sales volume, the North American Industry Classification System (NAICS) code, and other criteria. The six retail outlets included supermarkets, small grocery stores, convenience stores, fruit and vegetable markets, meat markets, and meat market+small grocery stores. Restaurants could be classified as either limited service restaurants (LSR) or full service restaurants. For this study, small grocery stores, fruit and vegetable markets, and meat market+small grocery were combined into one variable called small grocery. Only the following four outlets were used in analysis, based on their relationship with eating behaviors: supermarkets, small grocery, convenience stores, and LSR.

The distance between food outlets and respondent's homes were determined by GIS mapping using Esri ArcMap with Network Analyst (version 10.3.1) using network walking distance. Each year, a custom road/path network was built to include parks and pathways and exclude highways. In the four cities used in analysis in this study, there were more LSR and convenience stores near respondent's homes and fewer small grocery stores and supermarkets. A ¼ mile radius was used for LSR and convenience stores, as 97% of households had an LSR and 99% had a convenience store within ½ mile. A ½

mile radius was used for small grocery stores and supermarkets, as only 8% of households had a supermarket and 16% had a small grocery within ¼ mile.

Statistical Analysis

Descriptive analyses were conducted using t-tests for continuous variables and chi-squared for categorical variables.

Multivariable analysis: Model fit testing based on examination of Akaike's information criterion (AIC) revealed that gamma regression with a logarithmic link function had the best fit. In this study sample, the distributions of the dietary behaviors were positively skewed. In gamma regression, the antilogarithm of the regression coefficient, e^b, represents the proportional differences in the outcome associated with a 1-unit increase in the independent variable. For this study, e^b is the proportional difference in frequency of food and beverage consumption associated with participating in SNAP, compared to income-eligible adults who do not participate in SNAP. For example, an e^b value of 1.50 for a food item would mean a 50% higher frequency of consumption of that food for those that participate in SNAP compared to those who do not participate in SNAP. Multivariable models were built based on significant bivariate associations of $p<0.10$, except for age, gender, race, city of residence, and panel, which were included in all models. Variables stayed in the multivariable model if the significant association remained after being added.

Interaction and stratified analysis: To test for interaction, an interaction term (SNAP participation##presence of food outlet) was included in the multivariable model and then separate, stratified analysis was used to determine the differences in associations between SNAP participation and eating behaviors by presence or absence of food outlets.

Preliminary analysis revealed no differences in results when using presence/absence or count of food outlets within a pre-defined radius, so presence/absence was used to be consistent with previous research using these data.[24] Two multivariable models were run: one with the subgroup of respondents who had the specific food outlet present within the defined radius and the second with the subgroup who did not have the specific food outlet present within the defined radius.

Sensitivity analysis was conducted which extended the income to 200% of the FPL and there were no significant differences in outcomes. All analyses were conducted in Stata (version 13.1). Individual associations were considered significant at $p<0.05$. Interactions were considered significant at $p<0.10$.

Results

Of the 983 respondents whose annual household incomes fell under 130% of the Federal Poverty Level, 60% participated in SNAP, 49% were between the ages of 35-54 years, 86% were female, 52% were non-Hispanic black, and 49% had a high school degree or equivalent (Table 5-1). There were significant differences in who participated in SNAP by age, gender, race/ethnicity, poverty status, and WIC participation. Of respondents ages 18-34 years, 66% participated in SNAP compared to only 49% of respondents ages ≥55 years. Female responded reported a higher rate of SNAP participation (62%) compared to males (47%). Non-Hispanic whites (60%) and non-Hispanic blacks (65%) had a higher percentage of SNAP participation compared to Hispanics (53%). Participation in SNAP was higher among respondents who also participated in WIC (69%) compared to non-WIC (56%). Lastly, respondents from panel 2, for which data were collected in 2014, had a higher rate of SNAP participation at 72%

compared to only 51% from panel 1, for which data was collected in 2009-10. In unadjusted analysis, SNAP participants had a higher daily frequency of soda (p=0.03), sweetened fruit drinks (p=0.002), and total SSB (p=0.001) consumption compared to income-eligible non-participants.

Table 5-1: Demographic characteristics and eating behaviors by participation in SNAP. Cross-sectional data of respondents with incomes under 130% of the Federal Poverty Level[a] collected from four New Jersey cities in 2009-10 and 2014 (n=983).

	All SNAP-Income Eligible Respondents (n=983)	**Not SNAP Participant** (n=395)	**SNAP Participant** (n=588)	**P-value for difference by SNAP participation**
	n (%)	n (%)	n (%)	
Age				0.003
18-34	375 (38.2%)	129 (34.4%)	246 (65.6%)	
35-54	486 (49.4%)	204 (42%)	282 (58%)	
55+	122 (12.4%)	62 (50.8%)	60 (49.2%)	
Gender				0.001
Male	136 (13.8%)	72 (52.9%)	64 (47.1%)	
Female	847 (86.2%)	323 (38.1%)	524 (61.9%)	
Race/ethnicity				0.004
Non-Hispanic white	40 (4.1%)	16 (40%)	24 (60%)	
Non-Hispanic black	513 (52.2%)	181 (35.3%)	332 (64.7%)	
Hispanic	410 (41.7%)	192 (46.8%)	218 (53.2%)	
Other	20 (2%)	6 (30%)	14 (70%)	
Education				0.83
Less than high school	285 (29%)	111 (39%)	174 (61.1%)	
High school or equivalent	478 (48.6%)	199 (41.6%)	279 (58.4%)	
Some college	183 (18.6%)	70 (38.3%)	113 (61.8%)	
College Graduate	37 (3.8%)	15 (40.5%)	22 (59.5%)	
Poverty status				<0.001
≤50% poverty level	272 (27.7%)	73 (26.8%)	199 (73.2%)	
50-99% poverty level	479 (48.7%)	195 (40.7%)	284 (59.3%)	
100-130% poverty level	232 (23.6%)	127 (54.7%)	105 (45.3%)	
WIC Participation				<0.001
No	710 (72.2%)	311 (43.8%)	399 (56.2%)	
Yes	273 (27.8%)	84 (30.8%)	189 (69.2%)	

Food Outlet Environment				
Small Healthy Outlet				0.18
Absence – ½ mile	590 (60%)	227 (38.5%)	363 (61.5%)	
Presence – ½ mile	393 (40%)	168 (42.8%)	225 (57.3%)	
Supermarket				0.08
Absence – ½ mile	647 (65.8%)	247 (38.2%)	400 (61.8%)	
Presence – ½ mile	336 (34.2%)	148 (44.1%)	188 (56%)	
Convenience Store				0.50
Absence – ¼ mile	169 (17.2%)	64 (37.9%)	105 (62.1%)	
Presence – ¼ mile	814 (82.8%)	331 (40.7%)	483 (59.3%)	
Limited Service Restaurant				0.23
Absence – ¼ mile	310 (31.5%)	116 (37.4%)	194 (62.6%)	
Presence – ¼ mile	673 (68.5%)	279 (41.5%)	394 (58.5%)	
Panel				<0.001
1 (2009-10)	572 (58.2%)	279 (48.8%)	293 (51.2%)	
2 (2014)	411 (41.8%)	116 (28.2%)	295 (71.8%)	
City of Residence				<0.001
Camden	331 (33.7%)	104 (31.4%)	227 (68.6%)	
Newark	315 (32%)	127 (40.3%)	188 (59.7%)	
New Brunswick	122 (12.4%)	72 (59%)	50 (41%)	
Trenton	215 (21.9%)	92 (42.8%)	123 (57.2%)	
	Mean (SD)	Mean (SD)	Mean (SD)	p-value
Fruit – all (daily)	0.92 (1.06)	0.94 (1.03)	0.91 (1.08)	0.72
Vegetables - all (daily)	2.16 (1.66)	2.18 (1.78)	2.15 (1.57)	0.79
Salad - all (daily)	0.69 (0.89)	0.71 (0.91)	0.68 (0.87)	0.53
Fast Food (weekly)	0.91 (1.42)	0.90 (1.46)	0.92 (1.40)	0.77
Sugar Sweetened Beverages – all (daily)	1.32 (1.79)	1.08 (1.46)	1.48 (1.97)	0.001
Soda (daily)	0.58 (1.11)	0.49 (0.96)	0.65 (1.20)	0.03
Fruit Drinks (daily)	0.74 (1.21)	0.59 (0.97)	0.84 (1.34)	0.002

SNAP= Supplemental Nutrition Assistance Program

Note: Chi-squared analysis used to determine p-value of difference among groups for categorical variables and t-tests were used to determine differences among eating behaviors.

Note: Numbers/percentages for SNAP participation sum across row to see differences of each variable by SNAP participation. Percentages may be over 100% due to rounding.

[a] Income requirements for SNAP participation

In adjusted, multivariate analysis (Table 5-2), SNAP participation was significantly associated with a 29% higher frequency of fruit drinks (p=0.02) and 20% higher frequency of total SSB consumption (p=0.04). Presence of a convenience stores within ¼ mile was associated with a 20% decrease in frequency of total SSB consumption (p=0.04) and a 27% decrease in frequency of fruit drink consumption (p=0.02). Lastly, presence of an LSR within ¼ mile was associated with a 16% higher frequency of vegetable consumption (p=0.01). Sensitivity analysis revealed no differences in demographic variables or outcomes when participants with missing variables were included in the models.

Table 5-2: Associations of frequency of consumption of selected food and beverage items with participation in SNAP (yes/no) and with presence of various food outlets. Cross-sectional data of adult respondents with incomes below 130% of the Federal Poverty Line[a] collected from four New Jersey cities in 2009-10 and 2014 (n=983).[cd]

Food and beverage items	**Association with SNAP Participation (vs. not participating)**		**Presence of Small Grocery within ½ mile**		**Presence of Supermarket within ½ mile**		**Presence of Convenience Store within ¼ mile**		**Presence of LSR within ¼ mile**	
	e^b (CI)	p-value	e^b (CI)	p-value	e^b (CI)	p-value	e^b (CI)	p-value	e^b (CI)	p-value
Fruit – all (daily)	0.88 (0.75, 1.03)	0.11	1.10 (0.94, 1.28)	0.24	1.04 (0.88, 1.22)	0.64	1.02 (0.84, 1.23)	0.86	1.11 (0.95, 1.30)	0.19
Vegetables – all (daily)	0.96 (0.86, 1.06)	0.42	0.97 (0.87, 1.07)	0.51	0.97 (0.87, 1.09)	0.65	0.96 (0.85, 1.09)	0.53	1.16 (1.04, 1.28)	0.01
Salad (daily)	0.91 (0.76, 1.08)	0.29	0.98 (0.83, 1.16)	0.84	1.03 (0.85, 1.23)	0.79	1.00 (0.81, 1.24)	0.98	1.17 (0.99, 1.39)	0.07
Fast Food (weekly)	0.90 (0.73, 1.10)	0.30	0.99 (0.81, 1.20)	0.89	0.94 (0.76, 1.17)	0.60	1.01 (0.79, 1.29)	0.93	1.13 (0.92, 1.39)	0.24
Sugar Sweetened Beverages – all (daily)	1.20 (1.01, 1.44)	0.04	0.94 (0.79, 1.11)	0.48	1.01 (0.85, 1.22)	0.88	0.80 (0.65, 0.99)	0.04	1.09 (0.92, 1.31)	0.32
Soda (daily)	1.04 (0.80,	0.79	0.92 (0.73,	0.51	0.95 (0.74,	0.72	0.92 (0.68,	0.59	1.13 (0.88,	0.35

	1.35)		1.17)		1.23)		1.24)		1.45)	
Fruit Drinks (daily)	1.29 (1.04, 1.60)	0.02	0.95 (0.77, 1.18)	0.66	1.05 (0.84, 1.32)	0.64	0.73 (0.57, 0.95)	0.02	1.07 (0.86, 1.33)	0.56

SNAP= Supplemental Nutrition Assistance Program; LSR=Limited Service Restaurant; e^b = antilogarithm of regression coefficient and represents the proportional difference in frequency of food or beverage consumption with participation in SNAP vs not those who do not participate.

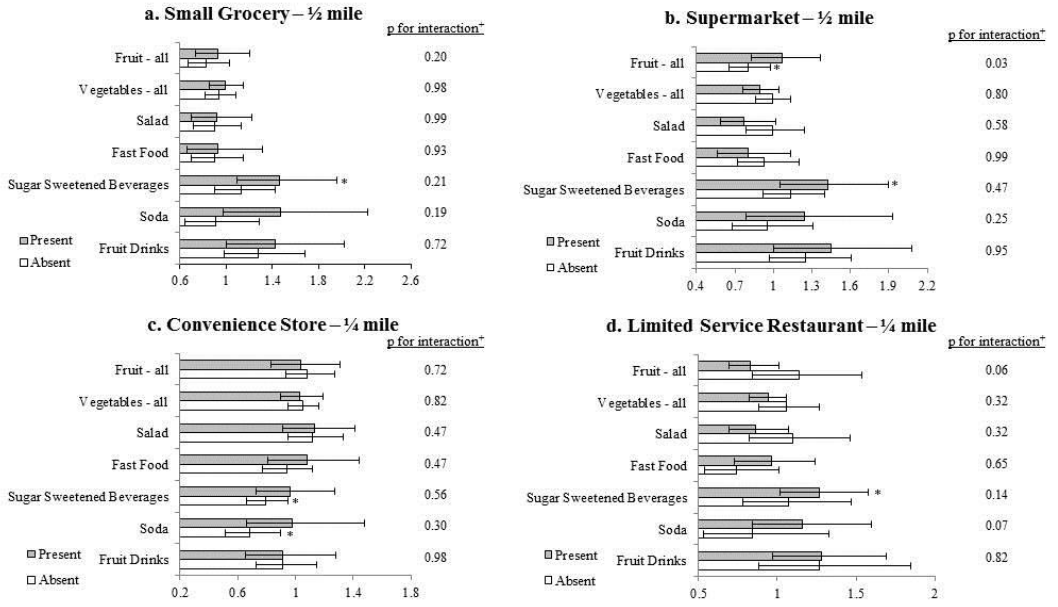
[a] Income requirements for SNAP participation

[c] Separate models were run for each food item and each food outlet

[d] Each model used gamma regression and was adjusted for age, gender, race/ethnicity, education, city of residence, panel (year of collection), WIC participation, and income

Stratified analyses (Figure 5-1, complete data found in Supplementary Tables 5a-d) reveal that the association between SNAP participation and eating behaviors varies depending on the presence or absence of certain food outlets. Among those living within a ½ mile of a small grocery store, SNAP participation was associated with a 42% higher consumption of fruit drinks (e^b=1.42, CI: 1.00, 2.02) and 46% higher consumption of total SSB (e^b=1.46, CI: 1.09, 1.09), compared to income eligible non-SNAP participants.

Figure 5-1: Stratified analysis of the association between SNAP participation and eating behaviors, based on presence or absence of a food outlet, and the significance of the interaction between SNAP participation and food outlet presence.



SNAP=Supplemental Nutrition Assistance Program.

*p<0.05 for association between SNAP participation and eating behavior, based on specific presence or absence of food outlet

+p-value from an independent model including interaction between SNAP participation and food outlet presence, fully adjusting for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

For those who did not live within ½ mile of a supermarket, SNAP participation was associated with a 20% lower frequency of fruit consumption (e^b=0.80, CI: 0.65, 0.98), compared to income-eligible non-participants. There was no association between SNAP participation and fruit consumption when respondents lived within ½ mile of a supermarket (e^b=1.07, CI: 0.83, 1.37). Respondents who lived within ½ mile of a supermarket had a significant association between SNAP participation and a 45% higher frequency of fruit drink (e^b=1.45, CI: 1.00, 2.08) and 42% higher frequency of SSB consumption (e^b=1.42, CI: 1.05, 1.90), compared to income-eligible non-participants.

Respondents who did not live within ¼ mile of a convenience store had a significant association with SNAP participation and a 21% lower frequency of total SSB consumption (e^b=0.79, CI: 0.66, 0.95) and 32% lower frequency of soda consumption (e^b=0.68, CI: 0.51, 0.90). There was no significant association between SNAP participation and total SSB (e^b=0.96, CI: 0.73, 1.27) or soda consumption (e^b=0.98, CI: 0.66, 1.48) when respondents lived within ¼ mile of a convenience store.

Lastly, respondents who lived within ¼ mile of an LSR had a significant association between SNAP participation and a 27% higher frequency of total SSB consumption (e^b=1.27, CI: 1.02, 1.58) and a marginally significant association with lower fruit consumption (e^b=0.83, CI: 0.69, 1.01), compared to income-eligible non-participants. There was no association between SNAP participation and total SSB (e^b=1.07, CI: 0.78, 1.47) consumption for respondents who did not live within ¼ mile of an LSR. Respondents who did not live within ¼ mile of an LSR had a marginally significant association between SNAP participation and a 26% lower frequency of fast

food consumption (e^b=0.74, CI: 0.54, 1.01), compared to income-eligible non-participants.

Discussion

This study was the first to examine how the community food environment influences the relationship between SNAP participation and consumption of food and beverages and can shed light on the mixed findings of previous studies that examined the association between SNAP participation and eating behaviors. Interaction and stratified analyses revealed that SNAP participation was associated with a higher consumption of SSB when respondents lived close to a small grocery store, supermarket, and LSR. There was a marginally significant association between SNAP participation and a lower frequency of fruit consumption when respondents did not live near a supermarket or did live near an LSR. Lastly, for respondents who did not live near an LSR, there was a marginally significant association between SNAP participation and a lower frequency of fast food consumption.

The research on SNAP participation and consuming SSB is mixed with some studies finding a positive association[6,25] and others not finding any significant association when compared to income-eligible non-participants.[7,8] Based on this study's findings, this discrepancy could be due to varying community food environments among study participants. While this study did find SNAP participation had a positive association with SSB consumption in the overall sample, this positive association disappeared when respondents did not live close to food outlets and only remained when respondents lived close to grocery stores, supermarkets, and LSR—outlets that sell SSB and often at low prices.[26] Past research has found that among low-income and SNAP populations, an

increase in food spending is associated with an increase in SSB consumption.[27] Because SNAP increases the purchasing power for food compared to income-eligible non-participants and SNAP participants have higher at-home food spending than income-eligible non-participants,[28,29] it would be a reasonable assumption that an increase in the food budget could lead to an increase in SSB consumption, based on prior research.

The positive association between food outlets and SSB consumption aligns with past research. A study among adolescents found that living within 800 m or 1600 m to restaurants, convenience stores, and grocery stores was associated with a higher SSB consumption.[15] Gustafson et al. found that shopping at supermarkets was associated with a higher SSB consumption.[30]

Many studies have examined the association between fruit and vegetable intake and the community food environment, and the results are generally consistent—those who live near supermarkets, farmer's markets, or healthy food stores consume more[9,14,31] while those who live near convenience stores and restaurants consume less.[31-33] This research aligns with the current study's result that SNAP participation was associated with a lower frequency of fruit consumption when respondents did not live near a supermarket or lived close to an LSR. If SNAP participants do not live near supermarkets, which are usually SNAP-authorized retailers and sell fruit at affordable prices, they may be choosing to spend their benefit dollars at SNAP-authorized convenience stores or small grocery stores that are more accessible, but usually sell lower quality produce and at higher prices, and sometimes do not sell fresh produce at all.[11,34] To improve the consumption of fruits and vegetables among SNAP participants, a pilot project by the USDA, the Healthy Incentives Pilot (HIP), provided 30 cents to

participants for every SNAP dollar spent on fruits and vegetables. The money was immediately credited back to the SNAP participant's Electronic Benefit Transfer card and could be used to purchase any SNAP-authorized food or beverage. The pilot results show that HIP participants consumed more fruits and vegetables than non-participants, spent more SNAP benefit dollars on fruits and vegetables than non-participants, and even spent more total money on fruits and vegetables than non-HIP participants.[35] This type of strategy may be helpful to 'overcome' the influence of the food environment for SNAP participants who do not live near supermarkets.

A recent systematic review of SNAP participation and eating behaviors found that of the four studies examining fast food intake, all four found that SNAP participants tend to eat less food away-from-home than non-participants.[4] The current study did not find a difference in fast food consumption between SNAP participants and non-participants overall or when respondents lived close to an LSR, but did find there was a marginally significant negative association with SNAP participation and frequency of fast food consumption when respondents did not live near an LSR. Past research on the association between proximity to LSR and frequency of consumption reveals those who live near fast food are more likely to consume fast food, especially for non-white populations.[16,36] However, given that SNAP benefit dollars are not accepted at restaurants, SNAP benefit dollars are spent less at away-from-home dining and more for at-home dining,[29] which would include food outlets such as convenience stores, small grocery stores, and supermarkets.

There are a few limitations to the current study. All respondent variables, including SNAP participation, income, and eating behaviors, were self-reported. SNAP

participation was gathered by asking if the respondent participated in the previous year while eating behaviors were asked for the prior month and therefore it could be the respondent was not currently enrolled in SNAP. Lastly, all data was cross-sectional so the results only reflect association and not causation between SNAP and eating behaviors.

This study also has many strengths. The classification process for food outlets was robust and based on published protocol, and included more in-depth analysis than what was received from the purchased dataset. Because GIS mapping was used, food outlet proximity could be determined based on each respondent's household rather than via census tract or block. The respondents came from a large, diverse sample that included low-income, minority populations, allowing for analysis for those most at-risk for obesity.[37] Lastly, information on WIC participation among respondents was also available, allowing for adjustment of this program, which has been shown to also influence eating behaviors.[38]

The role that SNAP plays in shaping food behaviors is complex, and this study elucidates that the community food environment may also play a role in shaping eating habits. While SNAP participation is associated with some unhealthy behaviors, this association is only significant when respondents live in certain food environments. Future research is needed to investigate SNAP participation and the community food environment longitudinally, to examine how these variables influence eating behaviors over time.

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Supplementary Table 5a: Stratified analysis of association of SNAP participation with frequency of consumption of selected food and beverage items for adult respondents with incomes below 130% of the Federal Poverty Line by presence or absence of a small grocery store within ½ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	SNAP Participation[a]				Interaction[b] (n=983)
	Small Grocery Absent (n=590)		Small Grocery Present (n=393)		
	e^{b} (CI)	p-value	e^{b} (CI)	p-value	p-value
Fruit - all	0.83 (0.67, 1.03)	0.09	0.93 (0.73, 1.20)	0.59	0.20
Vegetables - all	0.94 (0.82, 1.08)	0.36	0.99 (0.85, 1.15)	0.89	0.98
Salad	0.90 (0.72, 1.13)	0.35	0.92 (0.70, 1.22)	0.57	0.99
Fast Food	0.90 (0.70, 1.15)	0.40	0.93 (0.66, 1.31)	0.68	0.93
SSB - Total	1.13 (0.90, 1.42)	0.29	1.46 (1.09, 1.96)	0.01	0.21
Soda	0.91 (0.64, 1.29)	0.60	1.47 (0.97, 2.23)	0.07	0.19
Fruit Drinks	1.28 (0.98, 1.68)	0.07	1.42 (1.00, 2.02)	0.05	0.72

SNAP= Supplemental Nutrition Assistance Program; SSB=Sugar sweetened beverage; e^{b} = antilogarithm of regression coefficient

[a] Association of SNAP participation and eating behavior stratified by presence or absence of a small grocery store within ½ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

[b] P-value for independent model including interaction between SNAP participation and small grocery presence, also controlling for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

Supplementary Table 5b: Stratified analysis of association of SNAP participation with frequency of consumption of selected food and beverage items for adult respondents with incomes below 130% of the Federal Poverty Line by presence or absence of a supermarket within ½ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	SNAP Participation[a]				Interaction[b] (n=983)
	Supermarket Absent (n=647)		Supermarket Present (n=336)		
	e^{b}	p-value	e^{b}	p-value	p-value

	(CI)		(CI)		
Fruit - all	0.80 (0.65, 0.98)	0.03	1.07 (0.83, 1.37)	0.61	0.03
Vegetables - all	0.99 (0.86, 1.13)	0.84	0.89 (0.76, 1.04)	0.15	0.80
Salad	0.99 (0.79, 1.24)	0.95	0.77 (0.59, 1.02)	0.06	0.58
Fast Food	0.93 (0.72, 1.20)	0.58	0.80 (0.56, 1.13)	0.20	0.99
SSB - Total	1.13 (0.92, 1.40)	0.25	1.42 (1.05, 1.90)	0.02	0.47
Soda	0.95 (0.68, 1.31)	0.74	1.24 (0.79, 1.93)	0.35	0.25
Fruit Drinks	1.25 (0.97, 1.61)	0.09	1.45 (1.00, 2.08)	0.05	0.95

SNAP= Supplemental Nutrition Assistance Program; SSB=Sugar sweetened beverage; e^b = antilogarithm of regression coefficient

[a] Association of SNAP participation and eating behavior stratified by presence or absence of a supermarket within ½ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

[b] P-value for independent model including interaction between SNAP participation and supermarket presence, also controlling for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

Supplementary Table 5c: Stratified analysis of association of SNAP participation with frequency of consumption of selected food and beverage items for adult respondents with incomes below 130% of the Federal Poverty Line by presence or absence of a convenience store within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	SNAP Participation[a]				Interaction[b] (n=983)
	Convenience Store Absent (n=188)		Convenience Store Present (n=814)		
	e^b (CI)	p-value	e^b (CI)	p-value	p-value
Fruit - all	1.08 (0.93, 1.27)	0.32	1.04 (0.83, 1.31)	0.73	0.72
Vegetables - all	1.05 (0.95, 1.16)	0.32	1.03 (0.90, 1.19)	0.66	0.82
Salad	1.12 (0.95, 1.33)	0.17	1.13 (0.91, 1.41)	0.28	0.47
Fast Food	0.94 (0.77, 1.12)	0.46	1.08 (0.81, 1.44)	0.60	0.47

SSB - Total	0.79 (0.66, 0.95)	0.01	0.96 (0.73, 1.27)	0.78	0.56
Soda	0.68 (0.51, 0.90)	0.01	0.98 (0.66, 1.48)	0.94	0.30
Fruit Drinks	0.91 (0.73, 1.15)	0.45	0.91 (0.65, 1.28)	0.58	0.98

SNAP= Supplemental Nutrition Assistance Program; SSB=Sugar sweetened beverage; e^b = antilogarithm of regression coefficient

[a] Association of SNAP participation and eating behavior stratified by presence or absence of a convenience store within ¼ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

[b] P-value for independent model including interaction between SNAP participation and convenience store presence, also controlling for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

Supplementary Table 5d: Stratified analysis of association of SNAP participation with frequency of consumption of selected food and beverage items for adult respondents with incomes below 130% of the Federal Poverty Line by presence or absence of a limited service restaurant within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 and 2014.

Food and beverage items	SNAP Participation[a]				Interaction[b] (n=983)
	LSR Absent (n=310)		LSR Present (n=673)		
	e^b (CI)	p-value	e^b (CI)	p-value	p-value
Fruit - all	1.14 (0.84, 1.54)	0.41	0.83 (0.69, 1.01)	0.06	0.06
Vegetables - all	1.06 (0.88, 1.27)	0.53	0.94 (0.82, 1.06)	0.31	0.32
Salad	1.10 (0.82, 1.46)	0.52	0.86 (0.69, 1.07)	0.18	0.32
Fast Food	0.74 (0.54, 1.01)	0.06	0.96 (0.73, 1.24)	0.74	0.65
SSB - Total	1.07 (0.78, 1.47)	0.67	1.27 (1.02, 1.58)	0.03	0.14
Soda	0.84 (0.53, 1.33)	0.45	1.16 (0.84, 1.60)	0.36	0.07
Fruit Drinks	1.27 (0.88, 1.85)	0.21	1.28 (0.97, 1.69)	0.08	0.82

SNAP= Supplemental Nutrition Assistance Program; SSB=Sugar sweetened beverage; LSR=Limited Service Restaurant; e^b = antilogarithm of regression coefficient

[a] Association of SNAP participation and eating behavior stratified by presence or

absence of a limited service restaurant within ¼ mile, using gamma regression adjusting for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

[b] P-value for independent model including interaction between SNAP participation and limited service restaurant presence, also controlling for age, gender, race/ethnicity, education, city of residence, panel, WIC participation, and income

CHAPTER 6

THE MODERATION EFFECT OF THE COMMUNITY FOOD ENVIRONMENT BETWEEN FRUIT AND VEGETABLE CONSUMPTION AMONG WIC PARTICIPANTS OVER TWO TIME POINTS

Abstract

Introduction: Consumption of fruit and vegetables in the United States remains below recommended levels and low-income households consume even less. Starting October 2009, the WIC program provided cash value vouchers to participants to purchase fruits and vegetables. It is unknown how fruit and vegetable consumption has changed since 2009, and if consumption varies based on the community food environment in which WIC participants live.

Methods: Data on 420 WIC participants were collected as part of the New Jersey Child Health Study via a household telephone survey in four cities in New Jersey. Data were collected from two cross-sectional panels, from June 2009-April 2010 and April-August 2014. Interaction and stratified analyses using negative binomial regression was used to determine differences in consumption of fruits and vegetables across the two time points, and by presence or absence of various food outlets in the community food environment.

Results: There were no differences in fruit and vegetable consumption between the two time points. Stratified analyses found no significant associations between panel and fruit or vegetable consumption by presence or absence of a food outlet.

Discussion: The lack of findings may be due to the low value of cash value vouchers received by WIC participants, which may not be enough to influence daily consumption. There is a need for higher value CVV for participants to meet recommended intakes and

more promotion of fruit and vegetable consumption–both within the WIC program and WIC-authorized stores.

Introduction

The 2015-2020 Dietary Guidelines recommends that adults consume 2 cups daily of fruit and 2½ cups daily of vegetables, based on a 2,000 calorie diet.[1] However, only 13% of adults meet the fruit recommendation and 9% meet the vegetable recommendation.[2] Compared to high income families, low income individuals consume even fewer fruit and vegetables.[3] While households making over $60,000 a year consume fruit approximately 0.9 times per day and vegetables 1.15 times per day, households making less than $20,000 consume fruit only 0.68 time per day and vegetables only 0.96 times per day. This disparity in consumption is problematic as fruits and vegetables are associated with a lower risk of cardiovascular disease,[4] diabetes,[5] and stroke.[6]

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) assists low-income families in purchasing food by providing vouchers for healthy, nutrient-dense food. WIC also provides nutrition education, referral to health services, and breastfeeding support. In 2007, the United States Department of Agriculture updated the WIC food package starting October 1, 2009 to include cash value vouchers (CVV) to purchase fruits and vegetables, among other changes.[7] In the state of New Jersey (NJ), CVV can be used to purchase fresh, canned, or frozen fruits and vegetables at WIC-authorized outlets.[8] The amount of CVV at the beginning of the guideline change varied by participant; children received $6 a month, women who were not breastfeeding received $8 a month, and breastfeeding women received $10 a month.[9] In June 2014, the NJ WIC program changed their stocking requirements for WIC-authorized stores. Prior to the change, stores were required to carry two different types of fruit and two different types of vegetables, either canned, fresh, or frozen. Starting in June 2014, WIC-

authorized stores had to carry two different types of fresh fruit and two different types of fresh vegetables.[10] According to a report by the National Academies of Medicine, from 2013-2016, redemption rates for the CVV averaged at 77%.[11] In 2015, only 56.9% of WIC participants in New Jersey had complete redemption of their CVV (defined as using at least 90% of the CVV).[10]

Studies examining WIC participants showed a generally positive change in fruit intake shortly after the food package change.[12,13] Odoms-Young found an increase in fruit consumption among WIC Hispanic mothers, but not among WIC children or African-American mothers six months after the WIC food package change.[14] Another study found a small but significant increase in mean fruit intake among WIC mothers and caregivers 6 months after the WIC food package change.[12] However, a study that looked at the longer-term impact of the new food package found no change in adult fruit and vegetable consumption 18 months after the guideline change.[15]

Interestingly, the new WIC guidelines also influenced WIC-participating stores. After the guidelines were implemented, WIC stores were more likely to carry low-fat milk, whole wheat bread, brown rice, fruit, and vegetables, items that were included in the revised WIC package.[16,17] However, no study to date has examined the role food stores have played in influencing the dietary behavior of WIC participants over time since the food package change. In addition, there appears to be a discrepancy in findings of the beneficial effect of the food package change when comparing the time immediately following the change to 18 months post-change.

This study aims to examine how WIC participant's fruit and vegetable consumption changed from the beginning of the food package change in 2009-10 to four

years later in 2014, and how the community food environment moderates this relationship. The hypothesis is fruit and vegetable consumption frequency increased from 2009 to 2014, after the introduction of fruit and vegetable vouchers in the WIC program, and consumption frequency will be greater among those who live near healthy food outlets and WIC stores.

Methods

Participant Data

Participant data were collected as part of the New Jersey Child Health Study, a longitudinal study investigating the role of the food and physical activity environment on children's health and weight status. Data were collected via a phone survey to 2,211 households in four cities in New Jersey: Camden, New Brunswick, Newark, and Trenton. The phone survey was collected during two cross-sectional panels: June 2009-April 2010 (panel 1) and again in April-August 2014 (panel 2). Adults could complete the survey if they had one child between the ages of 3-18 and made the food purchasing decisions for the household. The survey could be completed in either English or Spanish, and consisted of questions on demographics, health behaviors, employment status, eating behaviors, and physical activity behaviors.

Study Sample

The sample used for this analysis was limited to 420 survey respondents who stated they had participated in the WIC program during the prior year and were not missing any outcome or explanatory variables. Respondents were included in analysis based on self-report WIC participation and those who did not report participating in WIC

were dropped (n=1,750). Additionally, 41 respondents were dropped from the sample due to having one or more missing variables used in analysis.

Outcome Variables

Two eating behaviors were chosen for this study: the frequency of consumption of fruit and vegetables. The eating behavior questions began with the statement, "The next few questions are about different kinds of foods you ate or drank during the past month. Your best guess is fine. You can tell me number of times per day, per week, or per month." Frequency of fruit consumption was obtained by the question, "Not counting juice, how often did you eat fruit? Count fresh, frozen, or canned fruit." Vegetable consumption was an aggregate of four vegetable questions, "How often did you eat a green leafy or lettuce salad, with or without other vegetables," "Not including French fried or other fried potatoes, how often did you eat any other kind of potatoes such as baked, boiled, mashed potatoes, or potato salad?" "How often did you eat cooked or canned dried beans, such as refried beans, baked beans, bean soup, tofu, or lentils?" and "Not including what you just told me about, how often did you eat OTHER vegetables such as tomatoes, green beans, carrots, corn, cooked greens, sweet potatoes, broccoli, or any other kinds of vegetables?" Frequency was then calculated to be number of times per day for both fruit and vegetables. These questions were adapted from the Behavior Risk Factor Surveillance Survey and 2009-10 National Health and Nutrition Examination Survey.[18,19]

Explanatory Variables

The phone survey included several questions including age, gender, race/ethnicity, income/poverty status, education, and participation in WIC and the

Supplemental Nutrition Assistance Program (SNAP). The respondent's education level was gathered via the question, "What is the highest grade or level of school that you have completed?" Responses were then categorized into, "less than high school", "high school or equivalent," "some college," or "college graduate." Income was determined by the question, "During 2008/2013, what was your family's total income from all sources, before taxes and other deductions? Include job wages, public assistance, social security, child support, and any other sources of income." Income was then calculated to be a percentage of the Federal Poverty Level to determine poverty status. Race/ethnicity was determined by the question, "What is your race?" Responses were categorized into, "Non-Hispanic White," "Non-Hispanic Black," "Hispanic," and "Other." Participation in WIC was determined by the question, "Did anyone in your family living there receive WIC in 2008/2013?" If needed, the follow-up statement was provided, "WIC=Special Supplemental Nutrition Program for Woman, Infants and Children." SNAP participation was collected by the question, ""Did anyone in your family living there receive food stamps in 2008/2013?" If needed, the follow-up statement was given, "Food Stamps are also referred to as SNAP (Supplemental Nutrition Assistance Program) or as having an EBT card (Electronic Benefits Transfer.)"

Community food environment data were purchased from Nielsen[20] and InfoUSA[21] for the years 2008, for panel 1, and 2014, for panel 2, and outlets were classified according to previously published protocol.[22] Outlets were classified as either a supermarket, small grocery store, convenience store, fruit and vegetable market, meat market, meat market+small grocery, limited service restaurant (LSR), or full service restaurant. Classification of retail outlets were by North American Industry Classification

System (NAICS) code, store sales volume, and number of healthy items sold in the store. Classifications of restaurants were by name recognition and if a customer paid for their meal before receiving (limited service) or after receiving (full service) their food. For this study, small grocery stores, meat market+small grocery, and fruit and vegetable markets were combined into one small grocery store variable. A list of WIC-authorized stores was obtained from the New Jersey Department of Health for years 2009 and 2014. Analysis was completed for supermarkets, small grocery store, convenience store, LSR, and WIC-authorized stores.

The distance between WIC participant homes and food outlets were determined by GIS mapping using Esri ArcMap with Network Analyst (version 10.3.1) using network walking distance. A custom road/path network was created each year to include parks and pathways and exclude highways. Preliminary analysis revealed the distribution of food outlets varied by type of outlet. WIC-authorized stores, convenience stores, and LSR were located closer to participant's homes while supermarkets and small grocery stores were located farther from participant's homes. A ½ mile radius was used for supermarkets and small grocery stores due to limited variability within a ¼ mile radius; only 17.6% of WIC participants had a small grocery and 8.5% had a supermarket within ¼ mile. On the other hand, a ¼ mile radius was used for WIC stores, convenience stores, and limited service restaurants due to limited variability beyond a ¼ mile radius; 88.3% of WIC participants had a WIC store, 97.2% had an LSR, and 98.1% had a convenience store within a ½ mile radius.

Statistical Analysis

Descriptive analyses were completed using Chi-squared tests for categorical variables and t-tests for continuous variables.

Multivariable analysis: Negative binomial regression was used for multivariable analysis due to the outcome variables' skewed distributions with a large spread and excess zeroes. Inclusion of covariates in the multivariable model were determined by a bivariate association of $p<0.10$ and were kept in the model if the significant association remained. However, age, gender, race/ethnicity, and city of residence were included in all models regardless of statistical significance.

Interaction and stratified analyses: To test for an interaction, an interaction term (panel##presence of food outlet) was included in the multivariable regression models. Preliminary analysis revealed no significant differences when using count of food outlets or presence/absence so presence/absence was used to align with previous research using this data.[23] To determine differences in association between fruit and vegetable consumption and participant panel (date of data collection) by the community food environment, stratified analyses were conducted by the presence or absence of the food outlet within the pre-defined radius.

Sensitivity analysis was completed to limit survey respondents based on income under 185% of the Federal Poverty Level, the income eligible to participate in WIC, and no differences in results were seen. All analyses were conducted in Stata (version 13.1). Individual associations were considered significant at $p<0.05$ and interactions were considered significant at $p<0.10$.

Results

Of the 420 WIC participants, 87% were female, 57% were between the ages of 18-34 years, and 42% had a high school or equivalent education (Table 6-1). There were no significant differences between the two panels of participants by age, gender, race/ethnicity, education, or poverty status. A higher proportion of panel 2 respondents participated in SNAP (73%) compared to panel 1 (47%). There were also differences in the community food environment between the two panels; a larger proportion of panel 2 respondents had a supermarket present within ½ mile (37%) and a small grocery store present within ½ mile (51%) compared to panel 1 (26% and 35%, respectively). In unadjusted analysis, there were no significant differences in fruit or vegetable consumption between the two panels.

Table 6-1: Demographic characteristics and eating behaviors by which panel the data was collected (panel 1: 2009-10, panel 2: 2014). Cross-sectional data for all WIC participants collected from four New Jersey cities in 2009-10 and 2014 (n=420).

	All WIC Participants (n=420)	**Panel 1: 2009-10** (n=273)	**Panel 2: 2014** (n=147)	**P-value for difference by panel**
	n (%)	n (%)	n (%)	
Age				0.93
18-34	238 (56.7%)	156 (57.1%)	82 (55.8%)	
35-54	158 (37.6%)	101 (37%)	57 (38.9%)	
55+	24 (5.7%)	16 (5.9%)	8 (5.4%)	
Gender				0.21
Male	54 (12.9%)	31 (11.4%)	23 (15.7%)	
Female	366 (87.1%)	242 (88.6%)	125 (84.4%)	
Race/ethnicity				0.11
Non-Hispanic white	20 (4.8%)	14 (5.1%)	6 (4.1%)	
Non-Hispanic black	197 (46.9%)	116 (42.5%)	81 (55.1%)	
Hispanic	192 (45.7%)	135 (49.5%)	57 (38.8%)	
Other	11 (2.6%)	8 (2.9%)	3 (2%)	
Education				0.08
Less than high school	113 (26.9%)	78 (28.6%)	35 (23.8%)	
High school or equivalent	177 (42.1%)	115 (42.1%)	62 (42.2%)	
Some college	101 (24.1%)	57 (20.9%)	44 (29.9%)	

College Graduate	29 (6.9%)	23 (8.4%)	6 (4.1%)	
Poverty status				0.35
≤100% poverty level	218 (51.9%)	137 (50.2%)	81 (55.1%)	
101-185% poverty level	131 (31%)	84 (30.8%)	46 (31.3%)	
>185% poverty level	72 (17.1%)	52 (19.1%)	20 (13.6%)	
SNAP Participation				<0.001
No	185 (44.1%)	145 (53.1%)	40 (27.2%)	
Yes	235 (56%)	128 (46.9%)	107 (72.8%)	
Food Outlet Environment				
Small Grocery Store				0.002
Absence – ½ mile	249 (59.3%)	177 (64.8%)	72 (49%)	
Presence – ½ mile	171 (40.7%)	96 (35.2%)	75 (51%)	
Supermarket				0.02
Absence – ½ mile	296 (70.5%)	203 (74.4%)	93 (63.3%)	
Presence – ½ mile	124 (29.5%)	70 (25.6%)	54 (36.7%)	
Convenience Store				0.23
Absence – ¼ mile	81 (19.3%)	48 (17.6%)	33 (22.5%)	
Presence – ¼ mile	339 (80.7%)	225 (82.4%)	114 (77.6%)	
Limited Service Restaurant				0.64
Absence – ¼ mile	126 (30%)	84 (30.8%)	42 (28.6%)	
Presence – ¼ mile	294 (70%)	189 (69.2%)	105 (71.4%)	
WIC Stores				0.87
Absence – ¼ mile	172 (41%)	111 (40.7%)	61 (41.5%)	
Presence – ¼ mile	248 (59.1%)	162 (59.3%)	86 (58.5%)	
City of Residence				<0.001
Camden	134 (31.9%)	86 (31.5%)	48 (32.7%)	
Newark	113 (26.9%)	57 (20.9%)	56 (38.1%)	
New Brunswick	61 (14.5%)	49 (18%)	12 (8.2%)	
Trenton	112 (26.7%)	81 (29.7%)	31 (21.1%)	
	Mean (SD)	Mean (SD)	Mean (SD)	p-value
Fruit - all	1.07 (1.27)	1.02 (1.35)	1.17 (1.13)	0.25
Vegetables - all	2.34 (1.71)	2.33 (1.68)	2.34 (1.78)	0.95

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children
Note: Chi-squared analysis used to determine p-value of difference among groups and t-test used to determine difference in eating behaviors by panel.
Note: Numbers/percentages for panel sum across column to see differences between panels/time. Percentages may be over 100% due to rounding.

Table 6-2 shows the adjusted prevalence ratios between the key independent variables and fruit and vegetable consumption, adjusting for age, gender, race/ethnicity,

education, SNAP participation, and city of residence. There were no significant associations; however, the presence of a small grocery store within ½ mile was marginally associated with a 14% higher frequency of vegetable consumption (PR=1.14; CI 0.99, 1.31). Sensitivity analysis revealed no differences in demographic variables or outcomes when WIC participants with missing variables were included in the models.

Table 6-2: Adjusted prevalence ratios for frequency of consumption of fruit and vegetables with data collected at panel 2 (2014), compared to panel 1 (2009-10), and with presence of various food outlets. Cross-sectional data of WIC participants collected from four New Jersey cities in 2009-10 and 2014 (n=420). [ab]

	Food items			
	Fruit		**Vegetables**	
	PR (CI)	p-value	PR (CI)	p-value
Panel (2 vs. 1)	1.16 (0.92, 1.45)	0.21	0.97 (0.84, 1.13)	0.73
Presence of Small Grocery within ½ mile	1.11 (0.89, 1.37)	0.36	1.14 (0.99, 1.31)	0.06
Presence of Supermarket within ½ mile	1.17 (0.91, 1.49)	0.22	1.10 (0.93, 1.29)	0.26
Presence of WIC outlet within ¼ mile	0.84 (0.68, 1.04)	0.11	0.96 (0.84, 1.11)	0.61
Presence of Convenience Store within ¼ mile	1.03 (0.80, 1.34)	0.80	1.08 (0.91, 1.29)	0.36
Presence of LSR within ¼ mile	1.08 (0.86, 1.36)	0.51	1.16 (0.99, 1.35)	0.06

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children; LSR=Limited Service Restaurant

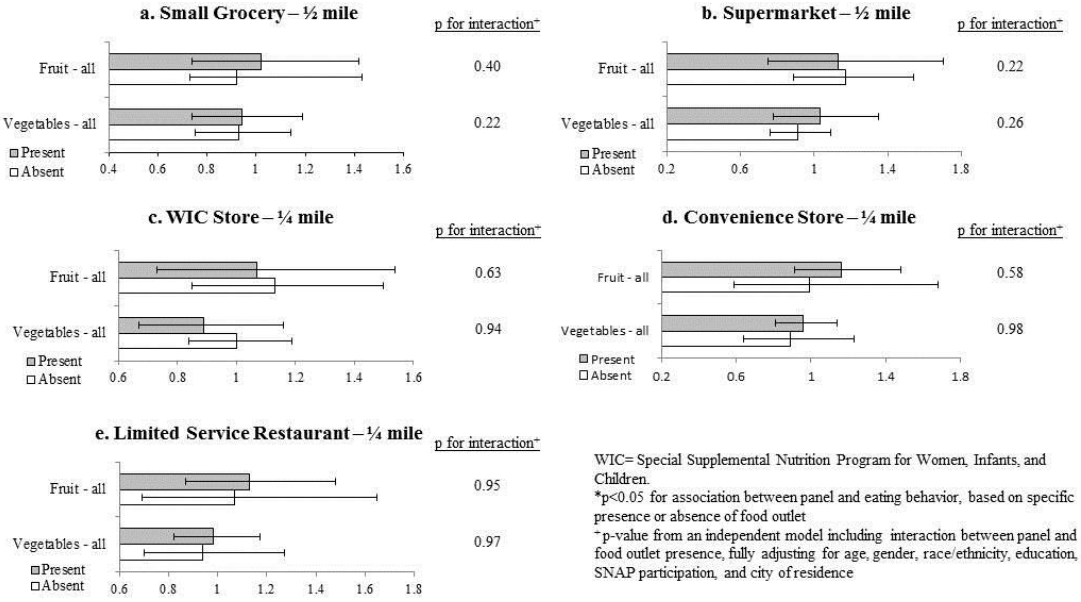
Note: Panel 1 coded as 1, panel 2 coded as 2

[a] Separate models were run for each food item and each food outlet

[b] Each model used negative binomial regression and was adjusted for age, gender, race/ethnicity, education, SNAP participation, and city of residence.

Stratified analyses (Figure 6-1, complete data shown in Supplementary Tables 6a-e) reveal no significant associations between panel and fruit or vegetable consumption by food outlet.

Figure 6-1: Stratified analysis of the association between panel and eating behaviors of WIC participants, based on presence or absence of a food outlet, and the significance of the interaction between panel and food outlet presence.



WIC= Special Supplemental Nutrition Program for Women, Infants, and Children.
*p<0.05 for association between panel and eating behavior, based on specific presence or absence of food outlet
+p-value from an independent model including interaction between panel and food outlet presence, fully adjusting for age, gender, race/ethnicity, education, SNAP participation, and city of residence

Discussion

This study was the first to examine the association of frequency of fruit and vegetable consumption among WIC participants across two time points five years apart, and how the community food environment moderated the relationship. Multivariable regression revealed no significant differences in fruit and vegetable consumption among adult respondents in WIC participating households between 2009-10 and 2014, and this did not change by presence or absence of various food outlets.

The lack of difference of fruit and vegetable consumption across time points does not align with two studies[12,14] examining short-term dietary changes before and after the food package change but does align with a study that examined differences over a length of time. Kong et al.[15] examined the dietary intake of WIC adult and child participants the summer before the new food package and again 18 months later. While they found that Hispanic children had an improvement in diet quality, there were no significant changes for WIC adult participants. However, two studies that examined differences six months post-guideline change did find an increase in fruit consumption, but not vegetable consumption, among WIC mothers or caregivers.[12,14] In general, WIC mothers have a low intake of fruits and vegetables; 99% of pregnant WIC mothers do not meet the recommended amount of vegetables and 64% do not meet the recommended amount of fruit.[11]

While the current study did not find a difference in fruit or vegetable consumption by the community food environment, a recent study in NJ did find variation in CVV redemption according to food access. Okeke et al. examined changes in CVV redemption in NJ before and after a statewide change in stocking requirements for WIC-authorized stores.[10] The study also examined if this change varied by access to a healthy food outlet within the participant's census tract. There was a 10% increase in full CVV redemption after the guideline change. When stratified by access to healthy food, there was no change in redemption for households without healthy food access while there was a 13% increase in households with healthy food access. However, there are a few differences in the current study compared to Okeke study. Okeke et al. examined CVV redemption compared to the current study's daily frequency of fruit and vegetable consumption. In

addition, healthy food access was by census tract rather than the current study's use of proximity. Lastly, the study used a different time period to examine changes by a statewide store requirement instead of the federal food package change. The results are compelling though that the community food environment may in fact influence WIC participant's CVV redemption.

One possibility for the lack of change of fruit and vegetable consumption over time is the amount of the CVV given for fruits and vegetables and if it could affect daily consumption. CVV values ranged from $6-10 a month per participant, which may not be substantial enough to see differences in daily fruit and vegetable consumption.[14] Redemption is also low in New Jersey; only 56.9% of WIC participants redeemed 90% or more of their CVV in 2015.[10] A recent report by the National Academies of Medicine recommended that the CVV amount would need to be increased to $41, based on a 2,300 calorie diet, to meet half of the Dietary Guidelines recommendations for fruits and vegetables. Their recommendation is to increase CVV amounts to $12 for children, $15 for pregnant women, $25 for post-partum women, and $35 for breastfeeding women.[11]

Another possibility for the lack of change in consumption in the current study is that WIC mothers are using the CVV as a replacement for spending their own money to purchase fruit and vegetables, rather than using the CVV to increase consumption. A systematic review of the use of CVV for the WIC program and a similar program in the United Kingdom, Healthy Start, found that while some women participating in these programs do use the vouchers to increase fruit and vegetable consumption, up to 66% of women used the vouchers to reduce food expenses so that money can be used for other bills. A study in New England found after the introduction of CVV, WIC participants

increased their fresh vegetable purchases by 17.5% and fresh fruit purchases by 28.6%, but they also found WIC participants substituted up to 13% of their produce purchases using WIC CVV instead of non-WIC funds.[24]

One feasible strategy to increase fruit and vegetable consumption among WIC participants is to promote fruits and vegetables within WIC-authorized stores. Thorndike et al. conducted a pilot study among six WIC-authorized stores to determine the influence of a store intervention in increasing sales of produce. Intervention stores increased the visibility of produce through new baskets, containers, refrigeration units, shelving units, or walls. Intervention stores increased fruit and vegetable sales by WIC participants by $40/month while control stores decreased sales by $23/month over a four month period.[25] A cross-sectional study that examined store characteristics with purchases found that stores which had a large shelf space devoted to fruits and vegetables, offered a greater variety of fruits and vegetables, and placed produce visible from the store entrance had higher produce purchases.[26]

There are several strengths to this study. The WIC participants were mostly from minority populations and lived in four cities across New Jersey. There were no differences in demographics across the two panels of data collection. In addition, the food outlet classification process was more rigorous than using purchased data alone, and was based on previously published protocol. Lastly, presence or absence of a food outlet within a defined radius was precisely measured by GIS-mapping WIC participant's homes to the nearest food outlet rather than using census tract or block data, a less precise method that is often used in other studies examining the community food environment.

However, there are some limitations to this study. One limitation is that while the frequency of food consumption was asked over the prior month, WIC participation was asked for the prior year. Thus, it is possible that some respondents were not actively a WIC participant at the time of the phone survey. In addition, the WIC food package guideline officially took effect October 1, 2009, in the middle of the data collection for panel 1 and so some data was collected during panel 1 after the vouchers began. Due to limited sample size, analysis of participants from panel 1 prior to October 1 was not feasible. There was also a statewide guideline change in NJ for WIC-authorized outlets during data collection of panel 2. Lastly, because this study used secondary analysis from the New Jersey Child Health Study, it is unknown if the lack of significant findings is due to not being significantly powered for the research question.

This study highlights the role of the WIC voucher program and its association with fruit and vegetable consumption among WIC participants across two time points. This study did not find a difference in consumption over time, which may reflect a need for higher value CVV for participants to meet recommended intakes and more promotion of fruit and vegetable consumption–both within the WIC program and within WIC-authorized stores.

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Supplementary Table 6a: Stratified analysis of prevalence ratios of panel with frequency of consumption of fruit and vegetables of WIC participants by presence or absence of a small grocery store within ½ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 (panel 1) and 2014 (panel 2).

Food items	Panel[a]				Interaction[b]
	Small Grocery Absent (n=249)		Small Grocery Present (n=171)		
	PR (CI)	p-value	PR (CI)	p-value	p-value
Fruit - all	0.92 (0.73, 1.43)	0.92	1.02 (0.74, 1.42)	0.89	0.40
Vegetables - all	0.93 (0.75, 1.14)	0.46	0.94 (0.74, 1.19)	0.62	0.22

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children
Note: Panel 1 coded as 1, panel 2 coded as 2
[a] Association of panel and eating behavior stratified by presence or absence of a small grocery store within ½ mile, using negative binomial model adjusted for age, gender, race/ethnicity, education, snap participation, and city of residence
[b] P-value for independent model including interaction between panel and small grocery presence, also controlling for age, gender, race/ethnicity, education, snap participation, and city of residence

Supplementary Table 6b: Stratified analysis of prevalence ratios of panel with frequency of consumption of fruit and vegetables of WIC participants by presence or absence of a supermarket within ½ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 (panel 1) and 2014 (panel 2).

Food items	Panel[a]				Interaction[b]
	Supermarket Absent (n=296)		Supermarket Present (n=124)		
	PR (CI)	p-value	PR (CI)	p-value	p-value
Fruit - all	1.17 (0.89, 1.54)	0.25	1.13 (0.75, 1.70)	0.57	0.73
Vegetables - all	0.91 (0.76, 1.09)	0.30	1.03 (0.78, 1.35)	0.85	0.29

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children
Note: Panel 1 coded as 1, panel 2 coded as 2
[a] Association of panel and eating behavior stratified by presence or absence of a supermarket within ½ mile, using negative binomial model adjusted for age, gender, race/ethnicity, education, snap participation, and city of residence
[b] P-value for independent model including interaction between panel and supermarket presence, also controlling for age, gender, race/ethnicity, education, snap participation, and city of residence

Supplementary Table 6c: Stratified analysis of prevalence ratios of panel with frequency of consumption of fruit and vegetables of WIC participants by presence or absence of a WIC-approved store within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 (panel 1) and 2014 (panel 2).

Food items	Panel[a]				Interaction[b]
	WIC Store Absent (n=172)		WIC Store Present (n=248)		
	PR (CI)	p-value	PR (CI)	p-value	p-value
Fruit - all	1.13 (0.79, 1.60)	0.51	1.07 (0.79, 1.44)	0.68	0.63
Vegetables - all	1.00 (0.78, 1.27)	0.99	0.89 (0.73, 1.08)	0.24	0.94

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children
Note: Panel 1 coded as 1, panel 2 coded as 2
[a] Association of panel and eating behavior stratified by presence or absence of a WIC store within ¼ mile, using negative binomial model adjusted for age, gender, race/ethnicity, education, snap participation, and city of residence
[b] P-value for independent model including interaction between panel and WIC store presence, also controlling for age, gender, race/ethnicity, education, snap participation, and city of residence

Supplementary Table 6d: Stratified analysis of prevalence ratios of panel with frequency of consumption of fruit and vegetables of WIC participants by presence or absence of a convenience store within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 (panel 1) and 2014 (panel 2).

Food items	Panel[a]				Interaction[b]
	Convenience Store Absent (n=90)		Convenience Store Present (n=339)		
	PR (CI)	p-value	PR (CI)	p-value	p-value
Fruit - all	0.99 (0.59, 1.68)	0.98	1.16 (0.91, 1.48)	0.24	0.58
Vegetables - all	0.89 (0.64, 1.23)	0.47	0.96 (0.81, 1.14)	0.64	0.98

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children
Note: Panel 1 coded as 1, panel 2 coded as 2
[a] Association of panel and eating behavior stratified by presence or absence of a convenience store within ¼ mile, using negative binomial model adjusted for age, gender, race/ethnicity, education, snap participation, and city of residence
[b] P-value for independent model including interaction between panel and

convenience store presence, also controlling for age, gender, race/ethnicity, education, snap participation, and city of residence

Supplementary Table 6e: Stratified analysis of prevalence ratios of panel with frequency of consumption of fruit and vegetables of WIC participants by presence or absence of a limited service restaurant within ¼ mile. Cross-sectional data collected from four New Jersey cities in 2009-10 (panel 1) and 2014 (panel 2).

Food items	Panel[a]				Interaction[b]
	LSR Absent (n=126)		LSR Store Present (n=294)		
	PR (CI)	p-value	PR (CI)	p-value	p-value
Fruit - all	1.07 (0.69, 1.65)	0.77	1.13 (0.87, 1.48)	0.36	0.95
Vegetables - all	0.94 (0.70, 1.27)	0.70	0.98 (0.82, 1.17)	0.79	0.97

WIC= Special Supplemental Nutrition Program for Women, Infants, and Children; LSR=Limited Service Restaurant

Note: Panel 1 coded as 1, panel 2 coded as 2

[a] Association of panel and eating behavior stratified by presence or absence of a limited service restaurant within ¼ mile, using negative binomial model adjusted for age, gender, race/ethnicity, education, snap participation, and city of residence

[b] P-value for independent model including interaction between panel and limited service restaurant presence, also controlling for age, gender, race/ethnicity, education, snap participation, and city of residence

CHAPTER 7

DISCUSSION

This body of work aimed to explore how the community layer of the Social Ecological Model (SEM), as represented by the community food environment, moderated the association between two layers of the SEM, the interpersonal layer and public policy layer, and individual eating behaviors. The large sample used in analysis allowed for multiple comparisons among sub-groups.

The first research question (HCP Advice Study) examined how the community food environment moderated the association between the interpersonal layer of the SEM, as represented by health care provider's (HCP) advice to lose weight, and four dietary behaviors: fruit and vegetable consumption, fast food intake, and sugar sweetened beverage (SSB) intake in an overweight and obese (OW/OB) sample.

The second research question (SNAP Study) examined how the food environment moderated the association between the policy layer of the Social Ecological Model, as represented by participation in the Supplemental Nutrition Assistance Program (SNAP), and four dietary behaviors: fruit and vegetable consumption, fast food intake, and SSB intake.

The third research question (WIC Study) examined how the association between the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program, representative of the policy layer of the SEM, and fruit and vegetable consumption changed across years before and after the food package change, and if the food environment moderated this relationship.

The community food environment was shown to be associated with the frequency of consumption of food and beverage items for both the HCP Advice Study and SNAP Study. However, there was no association of the community food environment with fruit and vegetable consumption in the WIC Study.

Sugar Sweetened Beverages

In the HCP Advice Study, OW/OB participants who received HCP advice to lose weight had a 33% lower frequency of fruit drink consumption and 29% lower frequency of total SSB consumption when they lived within ½ mile of a small grocery store, compared to OW/OB participants who did not receive HCP advice. For those who did not have a supermarket within ½ mile of their home, receiving HCP advice to lose weight was associated with a 21% lower frequency of total SSB consumption and 32% lower frequency of soda consumption. OW/OB participants who did not have a convenience store present within ¼ mile of their homes, receiving HCP advice to lose weight was associated with a 62% lower frequency of total SSB, 72% lower frequency of soda, and 42% lower frequency of fruit drink consumption. Lastly, among participants who did not have an LSR present within ¼ mile of their home, receiving HCP advice to lose weight was associated with a 24% lower total SSB consumption compared to those who did not receive advice. There was no association between HCP advice and SSB consumption when participants lived far from a small grocery store, near a supermarket, near a convenience store, or a near a limited service restaurant.

In the SNAP Study, low-income survey respondents who participated in SNAP had a 42% higher consumption of fruit drinks and 46% higher frequency of total SSB consumption, compared to income eligible non-SNAP participating adults, when living

within a ½ mile of a small grocery store. Among respondents who lived within ½ mile of a supermarket, SNAP participation was associated with a 42% higher frequency of total SSB consumption. Among respondents who lived within ¼ mile of an LSR, SNAP participation was associated with a 27% higher frequency of total SSB. Lastly, among respondents who did not live within ¼ mile of a convenience store, SNAP participation was associated with a 21% lower frequency of total SSB consumption and 32% lower soda consumption, compared to income-eligible non-participants. There was no association between SNAP participation and SSB consumption when respondents lived far from a small grocery store, supermarket, or LSR. There was also no significant association between SNAP participation and SSB consumption when respondents lived close to a convenience store.

Opposite effects on SSB consumption were seen with HCP advice to lose weight and SNAP participation. Receiving HCP advice to lose weight was generally associated with a lower SSB consumption while SNAP participation was associated with higher SSB consumption. Receiving HCP advice to lose weight would theoretically warrant a lower consumption of unhealthy foods/beverages, such as SSB. In contrast, SNAP provides additional funds for foods with limited restrictions on what types of food can be purchased.[149] Participants of SNAP, compared to income-eligible non-participants, have more money to spend on food and past research has found that having more money to spend on food is associated with consuming more SSB.[150]

Consumption of SSB remains high among U.S. adults, especially among minority and low-income populations. On average, adults consume around 7% of their total calories from SSB.[60] Non-Hispanic black and Hispanic adults are more likely to consume

any type of SSB than whites and non-Hispanic blacks are more likely to consume regular soda and sweetened fruit drinks than whites.[18] Adults with household incomes below 135% of the Federal Poverty Level (FPL) are more likely to consume SSB than adults with household incomes 300% or greater of the FPL. The research on SSB consumption among SNAP participants varies. A recent systematic review of the diet quality of SNAP participants found that among ten studies, four found a higher consumption among SNAP participants compared to non-participants while six did not find a difference between participants and non-participants.[43] The SNAP Study found that among low-income adults, those who participated in SNAP had a 20% higher frequency of total SSB consumption and 29% higher frequency of fruit drink consumption compared to income-eligible non-participants. However, the association with SNAP participation and SSB consumption was higher when respondents lived close to a small grocery store, supermarket, and LSR and the association was not significant when respondents lived far from a small grocery, supermarket, or LSR.

The influence of the community food environment on SSB consumption specifically is an interesting one as little research has been done previously among adults. Laska et al. examined the food environment and adolescent's SSB intake and found there was a positive relationship with having a fast food restaurant within 1,600 m of home and a convenience store within 1,600 m of home and higher SSB consumption.[35]

Other studies that have examined the food environment and SSB looked at shopping patterns rather than proximity to food outlets. French et al. found a positive relationship with fast food consumption and number of soda servings per day among women.[100] Similarly, a separate study of students found that visiting a fast food restaurant

within the past week was associated with a higher SSB consumption and there was a positive linear trend; the more visits to a fast food restaurant within the past week was associated with a greater number of SSB servings consumed.[101] These study results align with both the SNAP Study and HCP Advice Study. In the SNAP Study, there was an association between SNAP participation and higher SSB consumption when respondents lived near an LSR and lower SSB consumption when respondents lived far from a convenience store. While receiving HCP advice was associated with a lower SSB consumption among OW/OB respondents, when respondents lived near a convenience store or LSR, there was no significant association between HCP advice and SSB consumption, indicating a negative influence of these food outlets.

The association with SSB and the food environment is not limited to fast food outlets or convenience stores, research appears to show it may be access to SSB itself. Gustafson et al. found that adults who shopped frequently at a supermarket had higher odds of consuming SSB. Interestingly though, if the supermarket carried a larger variety of health foods, the participant's odds of consuming SSB were lower.[102] A study in Brazil examined the availability and variety of SSB among 52 census tracts and found that adults who lived near a large variety of SSB, regardless of the type of food outlet, were more likely to consume SSB than adults that did not live near a large variety.[36] This also aligns with both the SNAP Study and HCP Advice Study. Low-income respondents who lived close to a supermarket had a significant association between SNAP participation and a higher frequency of fruit drink and SSB consumption, compared to income-eligible non-participants. OW/OB respondents who received HCP advice had a lower frequency of total SSB and soda consumption when they did not live near a

supermarket, compared to those who did not receive advice. However, there was no association between HCP advice and SSB consumption when respondents lived close to a supermarket.

Price also appears to influence SSB consumption. A study examining the prices of soda at both convenience stores and supermarkets found that soda was 3 cents lower per ounce at supermarkets compared to convenience stores.[151] This may explain why there was a significant association between SNAP participation and SSB consumption when respondents lived close to a supermarket, but not close to a convenience store.

Given that the community food environment appears to influence SSB consumption, the question remains of what can be done to modify the food environment to make it easier to purchase healthy food. Policy changes such as a soda tax may be an effective way to decrease consumption. Cities that have implemented soda taxes have found a decrease in SSB consumption. After the soda tax took effect in Berkeley, California, consumption of SSB decreased 21%.[152] Implementing taxes across cities or states can be difficult and time-consuming though; feasible strategies are needed that can be implemented at the community or institutional level to improve diet. One example is using economic incentives within worksites. A pilot study by Block et al. increased soda prices by 35% in a worksite cafeteria and reported sales of soda decreased by 26%.[153] Another study within three hospitals discounted zero-calorie beverages by 10% and saw a 10% increase in sales of zero-calorie beverages.[154]

Beyond economic incentives or barriers, the use of nudging can also influence behavior. Nudging is defined as, "any addition to or modification of the environment that influences consumers in a predicable way, without changing economic incentive."[155]

Nudging strategies can be priming, which use subconscious cues, or salient strategies, which use relevant or vivid examples to increase attention to a particular choice. Priming strategies include changing the "choice architecture," such as making healthy foods first in a buffet line, placing them at eye-level on a shelf compared to top or lower shelfs, or simply changing the variety and assortment of foods available so that healthy foods/beverages are the majority offered. On the other hand, communication and/or educational tactics are used as salient nudging strategies. Both priming and salient nudging strategies have been associated with positive behavior changes.[156] These strategies are often used together in interventions to change behavior, as well as combined with economic incentives.

In a cafeteria intervention, a color code system for healthy (green) or unhealthy (red) items decreased SSB purchases by 24%. During a second phase, the researchers changed the visibility and accessibility of healthy items so they were easier to find and reach, which decreased SSB purchases by an additional 14% and increased healthy beverage purchases by 2%.[157] In the previously mentioned worksite cafeteria intervention by Block et al. which increased soda prices, an educational campaign was added as an additional stage after the 35% soda price increase and the researchers found soda purchases decreased an additional 18%.[153] A systematic review of nudging strategies concluding that priming and salient strategies are effective in influencing beverage choices and warrant future attention.[156]

Given the current studies' results on the association between SSB consumption and proximity to convenience stores and LSR, these pricing and educational strategies may be useful in the retail and restaurant environment. Unfortunately, there are few

studies examining these strategies with SSB consumption or purchases specifically as most interventions have focused on promoting healthy food, usually fruits and vegetables, rather than dissuading from unhealthy foods. An intervention in 23 food stores in the Marshall Islands used both mass media locally and in-store promotions, including educational shelf labels. The researchers found a decrease in regular soda consumption after the intervention and an increase in diet soda consumption among those who were exposed to the in-store promotions.[158] Even with limited published literature on the use of in-store strategies to reduce SSB, a systematic review of interventions in small food outlets found that all studies that used in-store promotions to promote specific foods found an increase in sales of those foods,[159] a promising finding for using these strategies to reduce sales and consumption of SSB.

The placement of products within retail outlets can influence perceptions of the product as well as purchasing behaviors. Perceptions of low-fat varieties of traditionally high-fat foods changed depending on if they were placed in a 'health food' section of a grocery store or if placed next to its traditional high-fat counterpart. In this scenario, the low-fat foods were considered less healthy when surrounded by health foods compared to when surrounded by high-fat foods.[160] It is unknown how the placement of SSB and diet sodas may influence perceptions, as no study has examined this, but the idea of changing perceptions or purchasing behaviors based on the placement of SSB within convenience stores is compelling and warrants future research.

The products placed around the checkout in retail outlets can also influence behavior. One study found that having to wait 25% longer in a checkout line resulted in a 17% higher likelihood of purchasing something near the checkout.[161] Given that the

majority of items near the checkout in food retail stores are SSB or candy, replacing SSB with water or calorie-free beverages may be another strategy to reduce SSB consumption in convenience stores and supermarkets.

While the current studies have found that access to supermarkets, convenience stores, and LSR is associated with a higher consumption of SSB, there are strategies that can be implemented within these outlets to curb purchases of SSB. Labeling and in-store education/promotion of healthy beverages, placement of SSB away from eye-level and checkouts, and pricing strategies may all be effective in reducing SSB consumption.

Fruit and Vegetables

In the SNAP Study, for low-income respondents who did not live within ½ mile of a supermarket, there was a significant association between SNAP participation and a 20% lower frequency of fruit consumption, compared to income-eligible non-participants. Among respondents who lived within ¼ mile of an LSR, SNAP participation had a marginally significant association with a 17% lower frequency of fruit consumption. There was no association between SNAP participation and fruit consumption when participants lived close to a supermarket or far from an LSR. In the WIC study, no difference in fruit and vegetable consumption was found between 2009-10 and 2014, and this did not change by presence or absence of a food outlet.

Many studies have examined the association between fruit and vegetable intake and the community food environment, and the results are generally consistent−those who live near supermarkets, farmer's markets, or healthy food stores consume more[31,32,97] while those who live near convenience stores and restaurants consume less.[32-34] This research aligns with the SNAP study that SNAP participation was associated with a lower

frequency of fruit consumption when respondents did not live near a supermarket or lived close to an LSR. If SNAP participants do not live near supermarkets, which are usually SNAP-authorized retailers and sell fruit at affordable prices, they may be choosing to spend their benefit dollars at SNAP-authorized convenience stores or small grocery stores that are more accessible. However, these stores also sell lower quality produce and at higher prices, and sometimes do not sell fresh produce at all.[121,162]

The results of the WIC study do not align with studies examining immediate effects of the food package change. Studies that examined changes six months after the guideline was implemented found positive changes in dietary intake[163] and fruit consumption.[124] However, one study that examined long-term (18 months) changes after the new food package found no significant differences in fruit and vegetable consumption among WIC mothers.[125]

One reason for the lack of change in consumption over time is that WIC mothers are using CVV to buy foods they previously bought with their own money, so they can then save money to use for other necessities. A systematic review of the use of vouchers for the WIC program and a similar program in the United Kingdom, Healthy Start, found that while some women participating in these programs do use the vouchers to increase fruit and vegetable consumption, up to 66% of women used the vouchers to reduce food expenses so that money can be used for other bills. A study in New England found there was a substitution effect of up to 13% of using WIC vouchers instead of non-WIC funds to purchase fruits and vegetables.[164]

Another reason for the lack of significant increases in consumption is the low value of the CVV. At the launch of the new guidelines, CVV values ranged from $6-10

per month and thus may not be a high enough value to see a significant increase in daily consumption.[124] Redemption is also low in New Jersey, as only 56% of WIC participants fully redeemed their CVV in 2015.[126] A recent report by the National Academies of Medicine recommended that the CVV amount would need to be increased to $41, based on a 2,300 calorie diet, to meet half of the Dietary Guidelines recommendations for fruits and vegetables. Their recommendation is to increase CVV amounts to $12 for children, $15 for pregnant women, $25 for post-partum women, and $35 for breastfeeding women.[165]

To improve fruit and vegetable consumption among WIC and SNAP participants, the same priming and salient nudging strategies can be used as with beverages. A meta-analysis of interventions which used such nudging tactics to increase fruit and vegetable purchases reported a moderate effect size (d=0.30), with a larger effect size (d=0.39) with using choice architecture to improve the visibility of the produce.[166]

A pilot study in WIC-authorized stores improved the visibility of produce and attractiveness of the produce stands, without using any educational or messaging strategies, and found fruit and vegetables sales through WIC CVV increased by $40 a month.[167] A cross-sectional study that examined store characteristics with purchases found that stores which had large shelf space devoted to fruits and vegetables, offered a greater variety of fruits and vegetables, and placed produce so it was visible from the store entrance had higher produce purchases.[168]

Given the positive effects seen with providing healthy foods in convenience stores, efforts are being taken to ‘convert’ convenience stores to provide healthier options. Both the Center for Disease Control and Prevention (CDC) and Institutes of

Medicine have recommended these strategies to incentivize convenience stores to start carrying healthier foods.[169,170] Within New Jersey, The Food Trust is actively working with small corner stores to begin carrying fruits, vegetables, and other healthy foods through the New Jersey Healthy Corner Store Initiative.[171]

Converting corner stores to start carrying fresh fruits and vegetables appears to work. Albert at al. converted three convenience stores to carry fruit and vegetables, as well as made general improvements in the attractiveness of the store. New refrigeration units were added to carry fruits and vegetables and existing tobacco and alcohol marketing materials were replaced with materials to promote fruit and vegetable consumption. Healthy foods were also placed near the store entrance while unhealthy snack foods were moved to the rear of the store. After the store conversion, there was a significant increase in fruit and vegetable purchases while there were no changes in purchases at the control stores.[172] A similar pilot study in Sacramento found that after installing a refrigerated produce case in a convenience store, sales of fresh produce increased about 26 pounds per week.[173]

While there was no difference in fruit or vegetable consumption in WIC participants between 2009-10 and 2014 in the WIC Study, strategies such as carrying more varieties and better looking produce as well as making produce highly visible within WIC-authorized stores may help improve fruit and vegetable consumption among WIC participants and even SNAP participants who shop at these stores.

A pilot project by the USDA, the Healthy Incentives Pilot (HIP), provided 30 cents to participants for every SNAP dollar spent on fruits and vegetables. The money was immediately credited back to the SNAP participant's Electronic Benefit Transfer

(EBT) card and could be used to purchase any SNAP-authorized food or beverage. The pilot results show that HIP participants consumed more fruits and vegetables than non-participants, spent more SNAP benefit dollars on fruits and vegetables than non-participants, and even spent more total money on fruits and vegetables than non-HIP participants.[174] This type of strategy may be helpful to 'overcome' the influence of the food environment. Given that in the SNAP Study, SNAP participation was associated with a 20% lower frequency of fruit consumption when participants did not live near a supermarket, providing financial incentives to purchase fruits and vegetables may encourage SNAP participants to shop for fruits and vegetables even if they do not live near a supermarket.

Fast Food

In the SNAP Study, among respondents who did not live within ¼ mile of an LSR, SNAP participation had a marginally significant association with a 26% lower frequency of fast food consumption, compared to income-eligible non-participants.

A recent systematic review of SNAP participation and eating behaviors found that of the four studies examining fast food intake, all four found that SNAP participants tend to eat less food away-from-home than non-participants.[43] Past research on the association between proximity to LSR and frequency of consumption reveals those who live near fast food are more likely to consume fast food, especially for non-white populations,[37,38] which aligns with this study's result that living farther away from LSR is associated with consuming less fast food. Given that SNAP benefit dollars are not accepted at restaurants, SNAP benefit dollars are spent less at away-from-home dining and more for at-home

dining,[175] which would include food outlets such as convenience stores, small grocery stores, and supermarkets.

While fast food was lower among SNAP participants than non-participants for those who did not live close to an LSR, fast food was still frequently consumed. Unadjusted analysis from the SNAP Study reveal low-income respondents ate at a fast food restaurant almost weekly (M=0.91, SD=1.42). This was slightly higher among OW/OB participants from the HCP Advice Study which had an average of once weekly (M=1.0, SD=1.58). This is problematic as those who consume fast food regularly have higher energy intakes, lower micronutrient intakes, and a higher BMI than those who do not.[10]

Menu labeling is one strategy that can be used at fast food restaurants to help patrons choose healthier options. One study found participants who ordered food from a menu with calories posted ate 14% fewer calories than participants who ordered food from a menu with no calories listed.[41] People who used menu labeling were also more likely to order healthier beverages and sides at fast food restaurants than people who did not use menu labeling.[110] As part of the Patient Protection and Affordable Care Act, restaurants with 20 or more locations will be required to post calorie information on menus beginning May 2018.[109] This law may help those who eat at LSR or fast food restaurants make healthier decisions.

Future Directions

There is still much work to be done to improve the diets of Americans and understand the role of the community food environment in shaping diets. More research is needed to understand the role of the community food environment in purchases and

consumption patterns of SNAP and WIC participations, so that changes can be made within stores shopped at by these program participants to positively influence the diets of these at-risk populations. Changes to program policies to either hinder unhealthy purchases or increase healthy purchases may also improve their dietary quality.

More research is also needed on the effectiveness of HCP advice to lose weight and which components improve its effectiveness. Understanding the role of the food environment in shaping patient's eating or drinking behaviors can aid physicians in making specific recommendations to patients.

Improving the community food environment is one strategy that research has shown to be successful in influencing food and beverage choices. By working within already-established food outlets, strategies such as offering healthy food and beverages in accessible areas, increasing the costs of unhealthy foods and beverages, providing messaging to educate consumers on healthy vs. unhealthy foods and beverages, menu labeling of calorie information, and improving the visibility and attractiveness of produce can make a difference in dietary behaviors.

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APPENDIX A

ABBREVIATIONS

AIC: Akaike's information criterion

BMI: Body Mass Index

BRFSS: Behavioral Risk Factor Surveillance System

C-NEEDS: Community Nutrition Environment Evaluation Data System

CDC: Center for Disease Control and Prevention

CSFII: Continuing Survey of Food Intakes by Individuals

CVV: Cash Value Vouchers

EBT: Electronic Benefits Transfer

FPL: Federal Poverty Level

GIS: Geographic Information System

HCP: Health Care Provider

HEI: Healthy Eating Index

HFA: Healthy Food Availability Index

HIP: Healthy Incentives Pilot

IHD: Ischemic Heart Disease

LSR: Limited Service Restaurant

NAICS: North American Industry Classification System

NEMS-S: Nutrition Environment Measure Survey for Stores

NHANES: National Health and Nutrition Examination Survey

NJ: New Jersey

OW/OB: Overweight and Obesity

SEM: Social Ecological Model

SES: Socioeconomic Status

SIC: Standard Industrial Classification

SNAP: Supplemental Nutrition Assistance Program

SSB: Sugar Sweetened Beverages

WIC: Special Supplemental Nutrition Assistance Program for Women, Infants, and Children

US: United States

VAT: Visceral Adipose Tissue